A COMPARATIVE ANALYSIS OF MATHEMATICS AND SCIENCE ACHIEVEMENT IN AN ALL-GIRLS SCHOOL

by

Delesa Franklin

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Chair of Committee: Dr. Virginia Rangel

Co-Chair of Committee: Dr. Keith Butcher

Committee Member: Dr. April Peters-Hawkins

Committee Member: Dr. Theresa Campos

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ABSTRACT

Background: There is continued emphasis on increasing student performance and interest in Science, Technology, Engineering, and Math (STEM), particularly among women. One solution has been the establishment of single sex schools. Some research suggests that girls enrolled in single-sex schools perform better in mathematics and science than their counterparts who are enrolled in coeducational schools, but more research is needed, particularly on public single-sex schools. **Purpose:** The purpose of this study was to compare the mathematics and science performance on the State Assessment of Educational Progress (SAEP) of eighth-grade girls in three schools in a large school district in Texas: a single-sex (all-girls) school and two co-educational schools from the same district. This study sought to determine if relationships existed between institution type, single-sex versus co-educational, and science and mathematics scores of eighth-grade girls while controlling for their race/ethnicity and socioeconomic status. **Theoretical Framework:** This study utilized the Expectancy-Value Theoretical Model to support the hypothesis that girls will have higher math and science achievement in a single-sex setting. The theory holds that individuals are motivated to behave based on the belief that they are able to accomplish the task of interest, that the task is enjoyable to them, that the task is personally or professionally relevant to them, and that completing the task will help them with future tasks or goals. **Methods:** A quantitative approach in the form of a nonequivalent group, post-test only quasi-experimental design was utilized in the study. This study utilized secondary data for eighth-grade female students from a single-sex school and two co-educational schools with similar demographic characteristics. The data included math and science scores, as measured by students'

SAEP student scores, as well as students' eligibility for free or reduced lunch and their race/ethnicity. The researcher estimated two multiple regression models to determine the relationship between institution type and math and science performance of the participants, controlling for race/ethnicity and socioeconomic status. **Findings:** The results of the regression suggest that students who attended the single-sex middle school scored significantly higher than students who attended the co-educational middle schools in both math and science. Asian students scored significantly higher than all other races in both math and science. There was no significant difference in the math or science scores based on economic vulnerability status. **Conclusions**: The results point to the effectiveness of educating adolescent girls in a single-sex school in the areas of math and science. Also, the results lead one to consider whether educating students in a single-sex school can help close the educational achievement gap that exists among different socioeconomic groups. Future research should explore the relationship between single-sex education and non-cognitive factors as well as the long-term social effects of single-sex schooling on attendees.

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CHAPTER I

INTRODUCTION

According to Sax, Arms, Woodruff, Riggers, and Eagan (2009), single-sex schools, especially those for girls, are a good option to address the gender inequities that have been documented in education. Comparing the behaviors, attitudes, and aspirations of female students from all-girls high schools with female students from coeducational high schools upon entering their first year of college, they find that single-sex secondary schools have a unique and positive influence on female students as they begin their post-secondary careers. The single-sex school refers to education at the elementary, secondary or postsecondary levels in which males or females attend school exclusively with members of their gender (Connecticut's State Education Resource Center, 2013). The National Association for Single-Sex Education (NASSPE) argues that girls attending single-sex schools are more likely to attend four-year colleges compared to girls attending a co-educational institution (NASSPE, 2016). In a separate study of girls in South Korea, where students were randomly assigned into single-sex or coeducational high schools, Park, Behrman, and Choi (2013) found evidence supporting NASSPE's claim: Girls at single-sex schools had higher GPAs and higher college entrance exam scores for college compared to their counterparts in co-educational schools. They also found that the single-sex schools produced a higher percentage of girls that attend four-year universities than do coeducational schools.

There are several potential reasons why girls may perform better in a single-sex school. For example, there is evidence that girls in co-educational classes tend to interact less with teachers, participate less, and are more likely to be harassed by boys (Eisenkopf, Hessami, Fischbacher, & Ursprung, 2015; Parker & Rennie, 2002). Girls in single-sex classrooms also may have higher overall self-confidence than their peers in co-educational schools (Eisenkopf et al., 2015). Lee, Needle, & King (2004) argue that when boys are removed from the environment, girls may be more willing to take risks than they would in a co-educational class. Finally, there is evidence that boys and girls learn differently and that single-sex schools can tailor the instruction to the one gender or another in a way that co-educational schools cannot (Eliot & Franklin, 2016).

Research also suggests that girls in single-sex schools perform better in math and science courses (Schneeweis & Zweimüller, 2012) and may be more likely to pursue careers in math and science (Sax, Arms, Woodruff, Riggers, & Eagan, 2009). For example, Sax and colleagues (2009) report that three times as many alumnae of single-sex schools plan to become engineers as alumnae of co-educational schools and that women in single-sex independent schools are 4.4 times more likely to become engineers. Moreover, Park et al. (2013) found that at every grade level girls are more likely to choose STEM (science, technology, engineering, and math) courses when they are in single-sex settings. Finally, the National Coalition of Girls' Schools (2016) has indicated that girls in single-sex schools are three times more likely to become engineers over their counterparts in co-education schools.

Males and females have different dominant personality characteristics, and each approach learning differently (Park et al., 2013). In general, males have a more dominant personality than females. Having both genders in the classroom, especially in math and science (where males traditionally dominate) would be a disadvantage to the girls. Therefore, teachers must be trained to meet the needs of girls. In an all-girl environment, girls seem to do better academically and exhibit more confidence in their capability in math because of attending single-sex schools (Park et al., 2013). It is important to give girls the confidence they need to be successful in their abilities and single-sex classrooms create opportunities that might not necessarily exist in a coeducational setting (NASSPE, 2016).

Despite recent support for single-sex education, some believe that there is no advantage to attending a single-sex school. As an example, in 2005 The United States Department of Education (2005) reported on several studies that found there are no apparent positive effects on long-term indicators of academic achievement. Indeed, one of these studies, Garcia (1998) found advantages for co-educational schooling. The study compared the Scholastic Aptitude Test (SAT) scores of 12th-grade girls in single-sex and co-educational public high schools. The advantages found were for white females but not for Asian or African American females. Considering the lack of clarity concerning the findings, it follows that more research should be conducted involving the education of historically marginalized females in co-educational settings as opposed to single-sex educational settings.

This study sought to address the question of whether girls in single-sex schools have higher mathematics and science performance achievement relative to similar peers in co-educational settings. Although there are numerous studies about girls in single-sex schools, this research focuses on one public all-girls school in a large urban district. Previous studies regarding single-sex public schools focus primarily on schools with special admissions policies (Bracey, 2006; Mael, Alonso, Gibson, Rogers, & Smith, 2005) and few studies exist regarding the educational outcomes of all-girl public schools consisting of students from primarily low-income and historically marginalized backgrounds, including for STEM outcomes. The goal of the study was to extend our understanding of single-sex schools by examining the academic achievement of low-income, historically marginalized students from all-girls schools in the areas of mathematics and science.

Background of the Problem

Single-sex schools have been gaining momentum with more and more parents leaning towards these schools for their daughters, yet the single-sex public school phenomenon is relatively new, only coming into existence with the No Child Left Behind Act of 2001. According to the National Association for Single-Sex Public Education (NASSPE), 506 public schools offered single-sex classes and 116 schools were solely single-sex schools during the 2011-12 school year. Tichenor, Couture, and Heins (2012) examined the views of K-5 parents in a school with a population of 650 students. The school's instructional program included both single-sex and co-educational classes and allowed students to opt-out of single-sex classes with parent permission. The survey findings revealed that 95 parents of 31 percent of the students who participated in single-sex classes supported the program and believed that the environment improved the attitude, behavior, and confidence of their children. More recently, research regarding single-sex schools for females suggested that girls attending single-gender schools were significantly more likely to attend a four-year college compared to girls from co-educational schools, causing a significant increase in the number of single-sex schools and the number of students choosing to attend single-sex schools. Park, Behrman and Choi's (2012) study provided evidence that girls of single-sex schools were more likely than their peers at co-educational schools to attend four-year opposed to two-year junior colleges.

Women and Girls in Education. Historically there have been fewer educational opportunities for women and girls. For example, Grossman (1998) argued that girls continue to receive fewer opportunities to participate in classrooms and less feedback from teachers in comparison to males. Buchmann and DiPrete (2006) argued that there has been a significant improvement in women's educational accomplishments. They compared the academic performance of females and males and described the progress of females in capitalizing on their academic proficiencies to further their educational studies. Their study analyzes if the male-female gap is or is not institutional and whether the gap's root cause is biological or cognitive differences of both genders. According to the National Center for Education Statistics (2015), the enrollment of first-time collegiate females increased by 15 percent from 2004 to 2014. During this same timeframe, the percentage for males increased by 19 percent.

The findings of Buchmann and DiPrete (2006) along with additional research reveals that the gap for women attaining postsecondary degrees between men and women is steadily closing. Education in the United States has improved for women and they continue to excel, especially in the fields of mathematics, science, and technology (United States Department of Education, 2001). According to the Department of Justice and Equity (2017), 82.9% of women completed a post-secondary education in 2016, which was an increase from 71.2% in 2007. The National Center for Education Statistics (2015) report highlighted that more women completed doctoral degrees in comparison to men. The contributions that girls and women have made in education in the U.S. also points to the fact that they are actively involved in technical subjects that, traditionally, would be dominated by boys/men. According to Ashcraft and Breitzman (2012) female rates of information technology patenting increased. Twenty- years ago most companies did not have female inventors; but by 2005, 25% of these same companies had one or more female inventors. This validates a report by the Catalyst Knowledge Center (2017) which states that over the past twenty years there has been an increase in female involvement in science and engineering in this country. According to Yoder's (2017) report, in 2017, engineering degrees earned by females reached a 10-year high: women earned 21.3% of all engineering degrees at the bachelor's level, 27.7% at the master's level, and 23.5% at the doctoral level. The engineering area with the highest percentage of degrees earned by females was environmental engineering; 50% bachelors, 45.7% masters, and 48.7% doctoral degrees. Compared to the rest of the world, this is a huge improvement for girls and women education; hopefully, this trend will continue to grow based on enrollment and the graduation rate among females at all levels of the education strata.

Academic Achievement of Girls. The academic achievement of girls is very important specifically for math and science. These subjects are by no means the ultimate measure of academic achievement but will be used in the context of this research. McFarland, Benson, and McFarland (2011) suggested that single-sex classrooms do help female students in their math achievement because they are free from the distraction and intimidation of their male counterparts. Archival data was gathered on classrooms of a specific gender and entered into a recorded form. The results of this study suggested that math scores for females were much higher than those in a traditional setting. The results of this research also indicated that females in a gender-specific classroom performed higher than males in both a single gender and traditional class setting.

Research examining single-sex schools and its impact on female graduates has continued to advance. In a study using data on first-year college students in the United States, Sax (2009), found that women graduates of single-sex schools were more likely to plan engineering as their major, over female graduates from co-educational schools. This study examined the effects of student-faculty interaction on several student outcomes including degree aspirations. The study also stated that 48% of female graduates of single-sex schools rated above average in math compared to 37% of girls in coeducational schools, single-sex schools exhibit interest of 4.4 times greater in engineering careers than their peers in coeducational settings, and girls in single-sex schools scored 15 points on their SAT score over their counterparts. Certainly, today, fewer and fewer career paths are considered to be male-dominated fields.

Females are not only enrolling in math and science courses in large numbers but are also outperforming their male counterparts. Sadker and Sadker (1995) contended that before the days when females were deeply engaged in math and science, teachers unintentionally denied them opportunities in areas dominated by boys. They discovered that there are issues as to why girls' desire to participate in male-dominated professions. This is because of the whole notion that these were male subjects. Studies have shown that female students increased engagement in the areas when they are separated from the boys. Research also has shown that there is a positive connection between college entrance exams and college attendance rates of boys and girls from single-sex schools (Park et al., 2013). Also, more graduates from single-sex schools transitioned into four-year colleges compared to those who transition the coeducational graduates. The National Center for Education Statistics (2015) reported that females in math and statistics were 43.0% at the bachelor's level, 41.5% at the master's, and 28.9% at the Ph.D. level. Engineering was 18.4% at the bachelor's level, 24.4% at the master's, and 22.7% at the Ph.D. level.

Women in the STEM Workforce. Science, technology, engineering, and mathematics are changing the character of the workforce in the United States and it is evident that females are still underrepresented in STEM areas. Girls and women represent untapped human capital that, if leveraged, could enhance the STEM workforce, given that they comprise 50% of the American population and more than 50% of the college-bound population (Dasgupta & Stout, 2014). Although STEM workers are increasingly in demand, women occupy a small portion of the STEM labor market. Xu (2017) examined how female graduate numbers in STEM majors remain low, yet these females have a lower unemployment rate than non-STEM graduates. According to the National Science Board (2016), there is still a great disparity in engineering, computer, and the physical sciences and women remain underrepresented in these areas. The disproportion continues even though the number of females' enrollment in these science programs are on the increase. Women represent 57% of the total work population in the United States (US Department of Labor Statistics, 2016). Although they make up more than 50% of the college-educated working class, women represent a merely 29% of the science and engineering labor force (National Science Board, 2016).

In addition to the fact that there are few women in STEM areas, it has been found that there is a disparity of females within specific STEM areas. For example, the National

Science Foundation (NFS) found in 2015 that female engineers and scientists occupied other areas of employment outside their professions with over 62% in the social sciences, 48% in biological, agricultural and environmental life sciences, compared to 25% in mathematical sciences and 15% in engineering. The foundation reported that women represent 10.7% of electrical or computer hardware engineers, 11.1% of physicists and astronomers, 17.1% of industrial engineers, 17.5% of civil, architectural, and sanitary engineers, 22.7% of chemical engineers, 33.8% of environmental engineers, 35.2% of chemists, and 7.9% of mechanical engineers. The NSF (2015) provided a more detailed analysis of the disparity of females in the STEM field. Table 1.1 shows the number of scientists and engineers employed based on gender and the highest degree level for the year 2015.

Table 1.1 shows that a disparity exists at all levels of education for the employment of female scientists and engineers. The information proves that for all occupations, females represent 47% compared to 53% males. Of the workers with a bachelor's degree, 46% were females compared to 54% males. Of the workers with a master's degree, 44% were females compared to 56% males and 38% had doctorate degrees compared to 62% males.

For science occupations, overall, females represented 33% compared to 67% males, but of the workers with a bachelor's degree, 28% were females compared to 72% males. Of the amount with master's degrees, 40% were females compared to 60% males and 38% female had doctorate degrees compared to 62% male. For all mathematical scientists overall, females represent 44% compared to 56% males. The amount employed with a bachelor's degree, 31% were females compared to 69% males. The number of mathematical scientists with master's degrees was slightly different in that there were 53% females and males were lower with 47%.

For mathematical scientists with doctorate degrees, there were 36% females compared to 62% males. These alarming statistics just illuminate the prevailing disparity that exists in the STEM workforce. For engineering occupations, females represent 15% compared to 85% males but the number of workers with bachelor's degrees, 13% were females compared to 87% males. The amounts with Master's, 17% were females compared to 84% males and 14% had Doctorate degrees compared to 86% males.

Table 1.1

Scientists and Engineers Employed based on Gender and Highest Degree Level by year

	All degrees			Bachelor's			Master's			Doctorate	
Occupation	Female (%)	Male (%)		Female (%)	Male (%)		Female (%)	Male (%)		Female (%)	Male (%)
All occupations	47	53		46	54		44	56		38	62
Science occupations	33	67		28	72		40	60		38	62
Biological/life scientist	48	52		53	47		47	52		43	57
Agricultural/food scientist	48	52		52	48		53	53		25	75
Biological/medical scientist	53	47		61	39		52	48		45	55
Postsecondary teacher	38	62		40	60		42	58		39	63
Computer and information scientist	25	75		23	77		29	71		16	82
Computer/information scientist	24	76		23	77		29	71		17	81
Mathematical scientist	44	56		31	69		53	47		36	62

Occupation	All degrees		Bachelor's		Master's		Doctorate	
	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)	Female (%)	Male (%)
Chemist, biochemist	32	68	36	63	43	57	18	86
Physicist/astronomer	18	82	30	70	33	67	7	93
Engineering occupations	15	85	13	87	17	83	14	86
Aerospace engineer	13	88	12	88	13	87	17	83
Chemical engineer	23	79	23	79	31	75	13	88
Civil engineer	20	80	17	83	23	77	17	83
Electrical engineer	10	90	8	92	13	87	9	91
Mechanical engineer	9	92	8	92	9	91	8	92
Other engineers	18	82	16	84	23	77	25	75

(Adopted from National Science Foundation, 2015)

In addition, the U.S. Bureau of Labor Statistics (2015) reported that in 2015 there was a significant gender gap, with women in computer and engineering professions occupying only 25.8% of the STEM jobs. Further desegregation of the data shows that women occupied 34.2% of computer systems analysts' jobs, 21.0% of computer programmers, 17.9% software developers, 12.8% computer hardware engineers and, 11.3% of aerospace engineers (Catalyst, 2017). Despite this gap, a large number of females earning advanced degrees in math and science, Hirsch et al. (2017) anticipated great benefits of single-sex schools for female students, and its effectiveness will become visible in the long-term.   Sullivan (2006) found that girls who attend single-sex schools might tend to increase their future earning potential with more involvement in the STEM workforce. Generally, the STEM fields tend to have high paying jobs and if single-sex schools better prepare girls for these jobs, more of them will be employed in these fields.

The rates of science and engineering course taking for girls/women shift at the undergraduate level and gender disparities begin to emerge, especially for minority women (NSF, Science & Engineering Indicators, 2016). It is slightly better for women at the master's 1degree level, where the share earned by women increased in three areas (engineering, physical sciences, biological and agricultural sciences) and decreased in four areas. According to Bidwell (2017), there is an increase in the number of girls graduating with higher-level degrees in the STEM fields. Women made the largest gains at the doctoral level. Policymakers projected that many of the STEM jobs will be 71% in computing, 2% in mathematics, 16% in traditional engineering, 4% in life sciences, and 7% in physical sciences (U.S. Bureau of Labor Statistics, 2015). There is also the likelihood for girls to get a bigger piece of the pie thus, substantiate Sullivan's claim.

Because there is an increase in the number of girls getting a college education, there will be a reciprocal increase in the number of them employed in various prominent agencies in the society that makes employment decisions. The labor force participation in most developing countries remains substantially lower for young women than men. It, therefore, means that females will play a very significant role in shaping policies in the country. Rurry (2005), in his book on themes in the history of American schooling, stated that education has helped transform the philosophies and practices as it relates to the equity for females and its effect on society. Females have the propensity to occupy more influential jobs, placing them in a position to have a more effective role in society. The researcher for this study supports Rurry's (2005) claim that women can and will help to transform the philosophies and practices of education in any society

All-Girls Schools: An Historical Perspective. Some laws and policies shaped American education. One of the most prominent laws was the Elementary and Secondary Education Act (ESEA) of 1965, which created the country's first national goal to provide educational opportunities for all but with a focus on students from lower-income families (U.S. Department of Education, 2015). A major event that affected single-sex schooling occurred when the Title IX amendments of the Education Amendments of 1972 were passed. Title IX was founded on the premise of equal opportunity, equal access, and full integration and provided complete access to all functions of schooling regardless of gender. Title IX allowed for the separation of males and females in certain situations such as sex-education classes or when contact sports were involved. Several schools created single-sex classrooms in an attempt to produce separate classrooms for different genders (Rurry, 2005). The number of all-girl schools has increased (NASSPE, 2016) especially since the enactment of the 1972 Title IX of the Education Act. The results of the enactment saw girls infiltrate the traditionally "male" dominated field science and computer (Sax, 2016). There is a subsequent increase in the number of females entering the well-paid careers of science, math, and engineering (NASSPE, 2013; Sax, 2016)

Girls' Education in the 18th and 19th Centuries. The birth of American education began in the 1700s and was dependent on gender, class, race, and location. According to Madigan (2009) "dame schools" in the 1700s were single-sex seminaries for teacher training, women and girls were separated from boys and were prepared for professions such as caretaking, nursing, and teaching. The essay reviewed the historical summary of the educational experiences of women in America and concluded that expectations were different for boys and girls in the educational setting. Women were primarily educated in developing domestic skills (National Women's History Museum, 2007).

The education of women began in the mid-17th Century. During this period, women's education focused on caretaking skills such as teaching and nursing (Madigan, 2009). The advent of secondary schools in the 1800s started to flourish very quickly especially for young girls who were enrolled in what was known in those days as an academy (National Women's History Museum, 2007). In the early 1800s, several seminaries for women only were founded to provide girls with a liberal education, equivalent to high school education (Signorella, 2016).

The growth in educational opportunities for girls gained momentum after the passing of the earliest compulsory legislation on education, called the Compulsory Education Legislation and the National Teacher Association. This legislation required children 8 - 14 years of age to attend school for at least three months of the year (Diorio, 2013). The first school on record in the United States that offered an all-girls academic curriculum was in Troy, New York and was created by Emma Willard founded in 1814 (Myers, 2008). The school was later renamed after its founder in 1895. Although this was a private school, the founder at the time saw it necessary to offer girls an education that is very similar to what boys received. Its mission was to foster young women to love learning, develop an intellectual life, develop moral strength, and shape the qualities of leadership for her world. This school set the foundation for single-sex (all-girls) education. The mission of the Emma Willard School continues to play a significant role in contemporary society.

Girls' Education in the 20th Century. By the 1900s, single-sex education started to impact policies in education in the United States. The dramatic change and growth in single-sex education also forced different government administrations to enact policies that supported single-sex schools. The development and transformation of the education system in the US during this period started with the enactment of the Elementary and Secondary Education Act (ESEA) of 1965. The ESEA aims to improve the academic accomplishment of disadvantaged students and to ensure a literacy education for all (U.S. Department of Education, 1965). This act was the first serious attempt by the federal government to create a national goal that provides educational opportunities for all students especially those from lower-income brackets (U.S. Department of Education, 2015). This law, although modified and reauthorized by successive administrations it consistently maintains its original conception of serving the most disadvantaged students (Thomas & Brady, 2016).

In 1972, the government enacted Title IX of the Education Amendments Act, which forbids discrimination based on gender in any programs of education that obtain federal financial support (U.S. Department of Education, 2004). According to Onion (2014), World War II gave women a starting point to participate in science and engineering programs. The demands of what was often called "scientific manpower" and a shortage of civilian male workers prompted the government to take action on paving the way for girls to enroll in STEM careers.

Title IX also provides more opportunities for girls with the passing of the 1974 Women's Educational Equity Act (WEEA), such as assistance for pregnant teens to continue their education and help for females in nontraditional or male dominated fields

(Madigan, 2009). Despite these policies, the U.S. Department of Education (2004), reported that “girls do not take as many mathematics and science courses as boys, girls lose confidence in their mathematics and science ability as girls move through adolescence, and there are few women role models in the sciences” (p. 1).

Girls’ Education in the 21st Century. There was an amendment to the Women's Educational Equity Act of 2001, which stipulates that additional training and curricula materials relating to impartiality for girls and women in education be accessible for dissemination on a national basis (U.S. Department of Education, 2004). This amendment protects females as they pursue their educational goals. However, in 2001 the passage of The No Child Left Behind Act (NCLB) allowed for the removal of previous boundaries what boundaries that inhibit the establishment of single-sex public schools and classrooms (Madigan, 2009). Although NCLB was positive for single-sex public schools, the Every Student Succeeds Act (ESSA) of 2015, how are these two related created additional opportunities what opportunities to increase single-sex schools in the United States (U.S. Department of Education, 2015).NCLB dealt with policies to close achievement gaps (No Child Left Behind [NCLB], 2002). ESSA, on the other hand, is a reauthorization of the ESEA and the NCLB Acts but focused on goals that create an avenue students’ college and career readiness and success (U.S. Department of Education, 2015). According to Mathis and Trujillo (2016), ESSA is predominately an accountability system; test-based, that requires schools in the lowest 5% to have student interventions and disaggregate data by race and socio-economic class. It remains uncertain what changes and new policies current administration will put in place to increase achievement for girls, especially in STEM areas. Every Student Succeeds Act

(ESSA) created a new opportunity for advocates to fight for educational equity and equal opportunity for all children (Leadership Conference Education Fund, 2017). The U.S. Department of Education (2017) reported that they would work with the president to make available equal opportunities for all students to receive a quality education. This includes those in single-sex schools. Single-sex education generates opportunities that do not necessarily exist in a co-educational context (NASSPE, 2013). Consequently, male and female students in this setting generally have less distraction from the opposite sex, hence, better academic performance. This comes with no surprise because of the many opportunities opened for female students in an all-girl learning environment. With female students outnumbering males in the classroom at all levels, the opportunities only propel them, even more, to focus and pay more attention to their own educational advancement.

In the 19th century, when increasing numbers of women began going to college and entering the workforce, women primarily were welcomed into certain positions such as teaching, nursing, social work, etc. As technology began to develop at a rapid pace, increased demand for STEM education for boys and girls emerged. The federal government-initiated programs to increase education in STEM disciplines and to increase the number of STEM graduates. Despite the efforts of the federal government, women have always been underrepresented in STEM fields. Recently, the number of women in STEM fields has increased, but at a much slower rate than the increase in the number of males in STEM fields (Catalyst, 2018). While in secondary education women generally take an equal number of math courses as their male counterparts. However, upon entering college, the number of women taking math and science courses dramatically decreases. One reason that may explain the dramatic decrease in the enrollment of girls in math and science courses in college is teachers' perceptions of boy's and girl's ability about STEM education. According to Hargreaves, Homer, and Swinnerton (2013), teachers from elementary to secondary education tend to perceive boys' math ability as higher than girls. This perception may affect girls' confidence and aptitude for math and science, thereby discouraging them from pursuing future STEM opportunities.

Trends in Single-Sex Education. Research over the years proves that there is a significant improvement in the academic performance of girls attending single-sex schools (National Coalition of Girls’ Schools, 2016). For instance, women who attended single-sex schools tend to outscore their coeducational counterparts on the SAT. In the United States, there has been an increase in the number of single-sex public schools to more than 500 in the last 20 years (Morrison, 2014). Because of a new regulation by the ESSA and the U.S. Department of Education on single-sex education (Park et al., 2013), there is a growing number of co-educational schools experimenting with the idea of establishing single-sex classrooms within the dual educational setting. In 2002, only about a dozen public schools offered single-sex classrooms. By 2012, more than 500 public schools across the United States offered single-sex classroom educational opportunities. Single-sex schools in Texas also have experienced positive results concerning academic achievement. The Young Women's Leadership Academy in Fort Worth met all state standards under Texas's accountability system in 2012-13, receiving state distinction designations for performance on mandatory standardized academic assessments. This was a notable accomplishment considering the school's population is more than 70% economically vulnerable. All these experiments were done to improve the academic performance of girls in co-educational schools.

Statement of the problem

This study addressed the problem of how single-sex schools impact the academic performance of girls in math and science. Studies on single-sex have proliferated, with an increased interest in how students perform in these schools (Goodkind, 2013). Specifically, more studies are needed on the academic performance of girls in single-sex schools in an urban setting. In this study, the researcher sought to address this gap in the literature by focusing on eighth-grade girls in both co-educational and single-sex schools in urban settings to examine their performances in math and science.

Purpose of the Study

The purpose of this study was to compare the performance of girls in math and science at an all-girls school with that of girls at co-educational schools in the same district. This study accomplished this by testing the hypothesis that girls at an all-girls school outperformed their peers in math and science on the State Assessment of Educational Progress (SAEP) while comparing the math and science performance of the participants on the SAEP. This study controlled for student race/ethnicity and socioeconomic status.

Research Questions

The study was guided by the following research questions:

RQ1: What relationship exists between the institution type (single-sex versus coeducational) and the mathematics performance of eighth-grade girls, controlling for student race/ethnicity and socioeconomic status?

RQ2: What relationship exists between the institution type (single-sex versus coeducational) and the science performance of eighth-grade girls, controlling for student race/ethnicity and socio-economic status?

Research Hypotheses

H_{01}: There is no relationship between the institution type (single-sex versus co-educational) and mathematics performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

H_{02}: There is no relationship between the institution type (single-sex versus co-educational) and science performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

Theoretical Framework

To fully understand the intricacies of a single-sex classroom as it relates to girls, the researcher utilized the Eccles et al. (1983) Expectancy-Value Theoretical Model as the theoretical framework for this study. According to Eccles (1983), the expectancy-value theoretical model was initially based on persistence, performance, and effort of mathematics achievement of eighth-grade girls. Traditionally, math and science have been male-dominated areas. According to Lu and Anderson (2015), being surrounded by other females, opposed to co-educational environments improves girls' academic results. Booth and Nolen (2012) reported that girls in single-sex schools become academically competitive like boys. The theory has been applied in similar studies that seek to understand the underrepresentation of females in science and engineering (Jacobs, Davis-Kean, Bleeker, Eccles, & Malanchuk, 2005; Meece, Eccles-Parsons, Kaczala, Goff, &

Futterman, 1982; Wigfield & Eccles, 2000). This framework will be fully explained under the theoretical framework in Chapter II.

Methods

To conduct this study, the researcher used a quantitative, correlational design. This study utilized secondary data for eighth-grade female students from a single-sex school and eighth-grade female students from two co-educational schools with similar demographic characteristics selected from the same district. The data included math and science scores, as measured by the State Assessment of Educational Progress (SAEP). The study utilized descriptive statistics to describe the population and regression analysis to answer the research questions. The specific inferential and descriptive statistical analyses are detailed in Chapter III.

Significance of the Study

Before the No Child Left Behind Act, single-sex public schools were not allowed; however, this changed through a revision to Title IX. The U.S Supreme Court ruled on the legality of single-sex public education in the 1996 case of *United States v. Virginia*. This ruling concluded that single-sex teaching in the public sector is within the law if comparable courses and facilities are accessible to both sexes. The No Child Left Behind Act and the Every Student Succeeds Act (ESSA) of 2015 (U.S. Department of Education, 2015) contain provisions that facilitate single-sex teaching in public schools. These regulations led to the publication of new federal rules, which currently allow districts to create single-sex schools and classes, on condition that enrollment is voluntary, services and facilities are available to both genders, and comparable courses are offered.

This study should be of particular interest to parents, researchers, policymakers, and educators. For parents, the study provides findings that can assist in their decision-making process when choosing a school for their children. Researchers can learn more about the topic and opens doors for a more comparative analysis of single-sex classrooms and co-ed educational settings. Additionally, the study will provide policymakers with research that will assist them to make data-driven decisions about the education of the nation's girls as it relates to math and science.

Limitations

There are several limitations to this study. The student data represented only two academic years, 2014-2015 and 2015-2016. The study was restricted to girls in middle school, specifically eight grade girls and their math and science performance on the SAEP. Only data for students enrolled in pre-Advanced Placement classes were selected. The study compared data for two schools. The study analyzed only Level II performance on the SAEP. This was a correlational study and did not seek to determine a causal effect between the single-sex environment and student performance. The demographics under investigation limited the generalization of the findings. A study of this nature will not lead to a generalization due to the restricted population; however, it can help to lend support the argument that girls in single-sex schools perform better than girls in co-education.

Assumptions

The single assumption of the study was related to data integrity. It was presumed that the data collected from the Texas Education Agency met all standards applicable to data integrity.

Operational Definition of Terms

Included in this research are key terms that are often associated with single-gender research. These terms are used throughout the study and defined to ensure clarity of meaning when used in this study.

AAUW

The American Association of University Women is an advocacy, education, philanthropy, and research organization that promotes equity and education for women and girls (American Association of University Women, 2018).

Coeducational or dual education schools

Coeducational or dual education schools refer to mixed-sex schools which have male and female students attending the same school (Bracey, 2007).

Co-educational

Co-educational refers to a traditional, heterogeneous mixture of boys and girls in one classroom and school (Bracey, 2007).

ESEA

The Elementary and Secondary Education Act was passed into law as a part of President Lyndon Johnson's war on poverty. The statue funded primary and secondary education and emphasized equal access to education as well as established high standards and accountability (U.S. Department of Education, 1965).

ESSA

The Every Student Succeeds Act (ESSA) was signed into law by President Barak Obama and reauthorized the 50-year-old Elementary and Secondary Education Act (ESEA), the nation's national education law and longstanding commitment to equal opportunity for all students (U.S. Department of Education, 2015).

NASSPE

NASSPE is a non-profit organization dedicated to the advancement of single-sex public education for both girls and boys (National Association for Single Gender Public Education, 2016).

Pre-AP classes

Pre-AP classes are a fairly new term for classes that are meant to prepare high school students for Advanced Placement courses (college-level classes taken in high school) as well as college classes themselves (PrepScholar, 2018).

PEIMS

The Public Education Information Management System (PEIMS) encompasses all data requested and received by TEA about public education, including student demographic and academic performance, personnel, financial, and organizational information (Texas Education Agency, 2018).

Single-sex education

Single-sex education refers to education at the elementary, secondary or postsecondary level in which males and females attend exclusively with members of their sex (Connecticut's State Education Resource Center, 2013).

Single-sex classroom

Single-sex classrooms have only male students or female students in attendance (Connecticut’s State Education Resource Center, 2013).

SAEP

The State Assessment of Educational Progress (SAEP) is the annual assessment program for the state of Texas in reading and mathematics at grades 3–8, writing at grades 4 and 7, science at grades 5 and 8, social studies at grade 8, and end-of-course (EOC) assessments for English I, English II, Algebra I, biology and U.S history.

TAPR

The Texas Academic Performance Reports (TAPR) pull together a wide range of information on the performance of students in each school and district in Texas every year. Performance is shown disaggregated by student groups, including ethnicity and socioeconomic status. The reports also provide extensive information on school and district staff, programs, and student demographics (Texas Education Agency, 2017).

WEEA

The Women's Educational Equity Act (WEEA) program was enacted in 1974 to promote educational equity for girls and women, including those who suffer multiple discrimination based on gender and race, ethnicity, national origin, disability, or age, and to provide funds to help education agencies and institutions meet the requirements of Title IX of the Education Amendments of 1972 (Madigan, 2009).

Summary

This chapter presented the background and research problem for the study. It presented the purpose and questions that will guide the study, as well as the study’s significance, its limitations, and its assumptions. The chapter concluded with a brief explanation of the methods to be utilized in the study and a presentation of the operational definition of terms applicable to the study.

CHAPTER II

LITERATURE REVIEW

Chapter II examines research on girls' education and the benefit of single-sex schools. The information in this chapter provides research on single-sex schools and how they impact the academic achievement of females. The theoretical framework utilized in this study is provided along with the rationale for its selection.

Females in Single-Sex Schools

Existing studies find that girls increase their self-esteem and other self-worth in single-sex schools. Smith's (1996) stated that a student's self-esteem in single-sex schools may be due to higher cognitive self-worth and more freedom. Smith (1996) conducted a 10-year study at two co-educational high schools; one all-girls' and one all-boys' school. Smith examined the relationship of the school type and student achievement outcomes. In studying 1,300 student participants it was revealed that girls have more self-worth in a single-sex environment. Lee and Byrk's (1986) emphasized that girls from single-sex schools are more likely to choose friends based on academics rather than friends who are solely interested in socializing as opposed to learning. The study examined how girls from single-sex schools were more interested in math than co-educated peers and determined that females in all-girls settings spent more time on homework. According to Hamilton (1985), females that attend single-sex schools perform better in all subjects than their peers in co-educational schools. The results from examining 1146 students in Jamaica determined that high school students in single-sex schools outperform those of co-educational settings in every academic measure.

Research suggests that some teachers believe girls in the single-sex schools will perform better academically, have greater prominence for directive and control, and exhibit superior peer interaction (Madigan, 2009). According to Madigan (2009), girls tend to aim for roles such as secretaries, nurses, and teachers unless they have a different direction. The history of girls seeking such professions began with "dame schools" that developed in the 1700s to serve as seminaries for girls and women to prepare for caretaking professions. Since math and science are traditionally male-dominated areas, having separate classrooms will remove the fear of intimidation from boys, but also instruction and delivery of the curriculum. Although creating separate classrooms does not mean that every girl will do well, but the experience would allow a solid foundation for them to learn and in an all-girls' environment. After all, Hirsch et al. (2017) contended that girls in single-sex schools demonstrate superior improvement in computer applications and engineering than their counterparts in co-educational settings. Consequently, this research will examine the effects of single-sex schools and their influence on girls in middle school.

In light of the increase of parents who are opting for single-gender education, the NASSPE (2016) reported that the number of public schools in the U.S. that offer single-sex education has surpassed 1,000. This number includes both single-sex schools and single-sex classrooms within coeducational schools. With the increase in the number of single-sex schools, there are concerns about whether and in what ways single-sex schools influence or affect the academic achievement of these girls. Boys and girls have different innate abilities, including their biological make-up and how their brain works (NASSPE, 2016). Researchers have linked single-sex schools to increased college attendance rates and higher entrance exam scores for girls (Park et al., 2013). Their study of randomly selected students into single-sex versus coeducational high schools proved that single-sex schools have a higher percentage of four-year college graduates and a much lower percentage of those that attend junior or two- year colleges.

As it relates to disadvantages, critiques argue that single-sex education, promotes gender stereotyping, undermines gender equality. A single-sex setting may not prepare students for work or family life, make exclusion acceptable, doesn’t value diversity, deprives access to mainstream programs, and doesn’t allow students to socialize with the opposite sex. Stanberry (2018) argued that students in single-sex classrooms will one day live and work side-by-side with members of the opposite sex and single-sex schools limit opportunities for male and female students to experience working together at an early age. Both advantages and disadvantages of single-sex education can influence the social lives of girls as they navigate their way through the realms of careers and educational pursuits from middle school level to college, especially in the math and science areas.

Pahlke, Bigler, and Patterson (2014) indicated that co-educational, single-sex schooling might provide an environment that facilitates effective learning for students in which policymakers, educators, and scientists must know. Their investigation consisted of the reasoning of all-girls schools amongst school stakeholders. Pahlke and colleagues (2014) examined the rationales for single-sex schools related to gender differences, the interest of girls, girls’ in group preference, and discrimination. Their findings revealed that stakeholders and teachers supported each rationale for an all-girls setting due to several reasons. The learning atmosphere of girls are generally free of male influence and competitions, therefore, focus on building character for girls and emphasizing academic performance. The outcome is geared towards creating a learning atmosphere that is conducive for female students to concentrate on what matters most.

Girls in single-sex schools show more positive sex-role attitudes, better self-esteem, improved academic achievement, and career ambitions (Lee, Needle, & Kang, 2014; Park et al., 2013). Similarly, Hamilton (1985) found that females of single-sex schools perform better practically in all subjects than their peers in co-educational settings. Girls in single-sex schools receive more attention from their teachers and staff members create a more stimulating environment for girls (Sullivan, 2006). According to NASSPE (2016), there is a greater possibility for girls in single-sex schools to explore non-traditional career fields because the environment encourages the freedom to pursue other areas of interest without competition from the opposite sex.

Single-sex schools for girls in urban areas have also proved to improve their academic achievement. Riordan (1994) found that African American and Hispanic girls in low-income areas perform better academically than their counterparts in coeducational schools. Also, Noguera and Akom (2004) revealed significant academic improvements for female students who are historically marginalized and female students with low-income backgrounds. Pollard (1999) found positive results from a voluntary afterschool single-sex program at two predominantly African American schools. Pollard (1999) contests that the success of the program could be attributed to the culture of the school which included more successful role models who were able to relate to the students, the opportunity for leadership at the single-sex school, and the opportunity to take courses that are more relatable to the students. Consequently, single-sex schools can be considered an option for improving the academic achievement of girls with urban backgrounds.

Interest in STEM for Middle School Students

Since the early 20^{th} century, educators have recognized the middle grades as a turning point in academic achievement and student engagement for young adolescents who are experiencing a time of critical transition. During this period, adolescents are striving to define themselves as individuals and establish their standing within social groups. Although some students successfully progress through the middle grades, many students underperform academically as they attempt to establish their social standing among peers. As a result, educational reformers have turned to educational models that emphasize the social-emotional dimensions of education as well as giving attention to academic rigor (Coelho, Sousa, & Figueira, 2014). Educational leaders now offer the social spaces for establishing individual and group curiosity and the academic space to harness the intellectual curiosity and exploration characterized by this period of development. The middle grades offer educators a unique opportunity to introduce and establish a curiosity for STEM career fields. According to the President's Council of Advisors on Science and Technology [PCAST] (2010), it is at this key juncture in adolescents' lives that their interest in STEM must be roused. PCAST (2010) indicates that students who express interest in STEM fields in the eighth grade are three times more likely to pursue STEM degrees than students who do not express such an interest. Consequently, educators of middle school students must inspire students, especially females, students of color, and economically vulnerable students to learn STEM content (Elam, Donham, & Soloman, 2012).

The Importance of Math and Science Education for Girls

Math and science education in single-sex schools can increase students' critical thinking and problem-solving skills and, most importantly, ensure that more females become more interested in pursuing STEM fields. Strategies can be used to support females, especially in math. According to Weist (2014), teachers should require girls to go beyond the use of manipulatives in math and practice problem solving, emphasizing the need for girls to be encouraged to analyze problems and implement critical thinking skills. Math and science are core to the debate regarding the effectiveness of single-sex schools. Math anxiety is considered to be “the key social attitudinal variable that might account for sex differences in achievement and enrollment in mathematics courses” (Eccles & Jacobs, 1986, p. 375). Kouzes and Posner (2002) emphasized that campus leaders should challenge teacher mathematical pedagogies and the need to continuously address student gender and attitudes. Many researchers have conducted studies in this area, but the results remain inconclusive and the decisions are left for students and their parents to make decisions with conclusive data (Heneghan, 2004).

The Educational Research Newsletter (2017) reported a study in Canada comparing eighth-grade girls from a girls-only school to both boys and girls from co-educational classes and found that there is a difference. Not only do all students have math competence and math anxiety, but also the research found that girls from the girls-only school performed better. Most importantly though, the results concluded that girls in the all-girls school who take math and science accomplished better grades in these subjects and others later in their high school studies.

Hom's study (2014) showed that female students in a co-educational setting are less likely to take on a career in math and science. In another study NASSPE (2016) compared girl's performance in mathematics and found that girls in the co-educational settings scored 59% while those in single-sex schools scored 75%. Although this is an isolated study, it provided evidence to support that girls in single-sex perform better in math and science education. The New Leaf Academy (2017) reported that 14% of students in an all-girls school majored in math while in co-educational schools, only 3% of girls chose math as their main course of study. Conversely, females in single-sex schools are more likely to pursue courses in math and science and that single-sex institutions provide unique opportunities for girls (NASSPE, 2013). It is therefore crucial that "scientists, educators, and policymakers know that single-sex schooling is a more effective learning environment for students, compared with coeducational schooling especially in mathematics and science performance" (Pahlke et al., 2014, p. 1042). Importantly though, to create that effective learning environment for girls, policymakers must use the research data to implement guiding principles that will affect change and better monitor educational outcomes for girls.

When it comes to academic accomplishments, especially in math and science, educational experts claim that female students are doing better in math and science and are more likely to choose these subjects if they have experienced single-sex classroom environments (Schneeweis & Zweimuller, 2012). Scheneesweis and Zweimuller (2012) used natural variation in gender adjacent cohorts within schools and found that girls are more likely to select a male-dominated type of school at age 14 if they were exposed to a higher number of girls in previous grades. If exposed, girls are less likely to choose an all-girls setting. One possible explanation is that co-educational settings reinforce gender stereotypes and more competition from the opposite sex. The rivalry in the co-educational settings can result in lower self-esteem for girls, which can affect their educational pursuits. Notwithstanding though, The National Center for Education Statistics (2015) reported that there is an increase in bachelor's, master’s, and doctorate degrees earned by females in math and statistics, computer, and engineering in the last decade ever before.

There is no doubt that there is a growing trend in math and science education among female students especially in all-girls schools (National Center for Education Research, 2007). However, there is a disparity in degrees attained; females earned 78% of the bachelor’s degrees in psychology, 62% in biological sciences, 51% in chemistry, 46% in mathematics, 25% in computer sciences, 22% in physics, and 21% in engineering. The degrees for women at the master’s level was similar but at the doctoral level, less than 33% were obtained in computer sciences, physics, chemistry, math, and engineering.

NASSPE (2016), in support of single-gender public schools, indicated that there are prospects for girls in single-sex settings to pursue courses in math and science. Feniger (2011) emphasized the persistent gap in math and science as one of the main reasons for the renewed interest in single-sex education. Myers (2008) claimed that single-sex schools could help facilitate the improvement in academic achievement, especially for girls.

Minority Girls in Math and Science

The odds are against women in math and science and from all indications this trend may continue for some time. Females remain less likely to pursue education and careers in science, technology, engineering, and math (Berger, 2018). Landivar (2013) agreed that women are and will continue to be the minority in math and science fields in the United States. Moreover, there is evidence that women of color are not closing the gap as White and Asian women. They are, in a sense, the minority of the minority because in addition to being women serving in man-dominated fields, they also belong to a minority ethnic or racial group.

Even though the science and engineering workforce is more diverse, racial and ethnic minority groups of both males and females are inadequately represented (Catalyst, 2017). The National Science Board (2016) reported that in the hard sciences (biology, chemistry, and physics) there is a noticeable low involvement of males and females of racial and ethnic groups. From an ethnic perspective, minority women (Hispanics, Blacks, and American Indians/Alaska Natives) occupied just 11% of the science and engineering labor force, which is just 27% of the working population in the United States (National Girls Collaborative Project, 2017). Research shows that Black women on a whole represent 10% of scientists and engineers working in the country (Catalyst, 2017). The National Science Foundation and the National Center for Science and Engineering Statistics (2017) reported that one out of 10 scientists and engineers employed in America are minority women. According to Catalyst (2017), while the science and engineering labor force in the United States is more diverse than before, minority populations remain significantly underrepresented. However, for the past 10-20 years, the participation of females of all racial and ethnic groups in science and engineering is on the rise and female students on a whole have a 22% enrollment in advanced math and science courses but there is a lower enrollment rate for Black and Hispanic students, 15-17% respectively (Catalyst, 2017).

According to Lopez and Barrera (2014), even though college enrollment rates among young people have risen in recent decades, a Pew Research Center analysis of U.S. Census Bureau data shows that females outpace males in college enrollment. However, colleges and universities must be compelled to continue to work to enroll more historically marginalized females in math and science. This campaign hopefully will filter down to the primary and secondary schools and will serve as a motivation factor for girls to get involved in mathematics and science. Hom (2014) argued that schools should introduce girls to math and science at a very early age. Without an early start at a single-sex school, females may be less interested in mathematics and science and least likely motivated to pursue a STEM career.

Competing Explanations for the Benefits of All-Girls Education

Single-sex schools can serve as advantageous educational pathways to empower and help increase the academic achievement of girls. Connecticut's State Education Resource Center (2013) highlighted the pros and cons of single-sex education. Regardless of whether it is single-sex or co-education, both types will at some point or another, encounter advantages and disadvantages. Some of the advantages of single-sex education are that girls feel less pressure as they mature and develop and there is an increase in staff sensitivity and awareness of their gender difference. The Connecticut State Education Resource Center (2013) emphasized that single-sex education also improves peer interactions, offers positive same-gender role models, provides more opportunities to pursue academic and extracurricular endeavors without racial and gender stereotypes, and creates a less distracted than co-educational environments. According to Guarisco (2010), female students are generally pleased with single-sex classrooms and thrive in environments that motivate them to fully participate and share their candid opinions about difficult content and misconceptions while learning. This type of educational model has led to higher college placement rates and is a preferred school experience for female students. Single-sex education for females could help increase their confidence, motivation, and most importantly an interest in challenging STEM fields.

Stereotype Threat. Several frameworks have been utilized to study academic achievement and the performance of groups. One example is the stereotype threat, which has been applied to study both genders and other social groups in education and other fields. Stereotype threat studies confirm that there is one group that has a negative stereotype. Stricker (2008) stated research on the effects of high-stakes testing and how changes in assessments can help minimize the effects of stereotype threat. Stricker (2008) proposed that refinement is needed with test content, psychometrics, and the overall social context of testing. Situations, such as cognitive testing, have been used as examples of stereotype threat. Steele and Aronson (1995) experimented with stereotype threat. They administered a test created with rigorous verbal ability questions to African American and White undergraduate students in two studies. Their findings revealed that African American underperformed in comparison to Whites in the ability-diagnostic condition but not in the diagnostic condition (with Scholastic Aptitude Tests controlled). Their study helped define the stigmatization of minorities on standardized assessments. Sparks (2015) examined the differences and similarities of coping strategies utilized by African American students with an engineering major. Findings revealed that there were no statistical differences of a students' assessment scores of stereotype vulnerability of three university types: (1) Historically Black Colleges and Universities (HBCUs); (2) predominately White colleges; and (3) diverse educational institutions.

Ambady, Shih, Kim, and Pittinsky (2001) studied third-grade girls who completed a math task after their gender was highlighted. Their study allowed 7 and 8-year old boys and girls to solve math problems of various levels and found that the performance of girls, not boys, was affected when their gender was activated. Findings revealed that girls underperformed on the most difficult math problems. Spencer, Steele, and Quinn (1999) studied women and their performance in mathematics. Their study consisted of testing men and women participants. Half of the women participants in the study were told that their math test showed gender differences and half were told it did not show differences. Women were informed that the math test did not show gender differences improved their overall performance.

Although researchers have used the stereotype threat theory to examine gender stereotypes in educational studies, it was not selected as the framework for this study. This study will incorporate the stereotype threat via the attainment value of identity. Since this study aims to compare the performance of girls in math and science at a single-sex school with that of girls at co-educational schools, the expectancy-value theoretical model will be utilized.

Theoretical Framework

The Expectancy-Value Theoretical model was used as the theoretical framework for this study. Expectancy theory argues that we are motivated to behave in a certain way dependent upon the strength of the belief that (1) specific behaviors will result in specific outcomes, (2) our confidence in the belief that we are capable of achieving those outcomes and (3) that those outcomes have varying degrees of attractiveness dependent upon our perception that achieving the outcome will lead to attaining a second-level outcome (Caulfied, 2007). Eccles et al. (1983) used the expectancy-value model of achievement as a framework to fully understand the performance of early adolescents in the area of mathematics through competency beliefs in addition to subjective task values, which are attainment values, aligned with a child's interest and utility value.

The expectancy-value model includes the interaction of expectancies and values to predict outcomes such as engagement, academic achievement, and continuing interest. Nicholls (1989) suggested that students who believe they are capable of mastering schoolwork typically have positive expectations for success, high motivation, and achievement. His study found that people have different conceptions of ability and a person's theory of achievement affects their success. Wigfield (1994) used the expectancy-value theoretical model to examine the development and change of young children's achievement beliefs and values. Wigfield (1994) found that there are specific kinds of changes in a child's achievement beliefs such as age, conceptions, and values. Eccles et al. (1993) predicted that an individual's values to do well is a crucial component of his or her ability to make a choice, particularly in the areas of gender educational goals and occupations.

The Expectancy-Value framework is best suited for this study as I sought to determine if girls in an all-girls setting outperform their peers of co-educational settings in the areas of math and science. The benefits of a single-sex educational setting can help empower females and allow them to have better choices in life. The outcome of this study can add value to break the cycle of how females are under-represented in STEM fields. The quality of the workforce can change if more young females have an interest and are successful in the areas of math and science at a young age. This study will give additional research in providing policymakers, researchers, educators and parents about the comparison between single-sex and co-educational settings for female students and its effect on female academic achievement in math and science. This research is needed to make decisions about how we educate young females in the academic areas of mathematics and science and to determine if the institution type, single-sex versus co-educational, has a direct impact on the mathematics and science achievement of eighth-grade girls.

Summary

According to the National Center for Educational Statistics (1995), women have made progress in education in the last two decades. More females apply to college and seek college degrees. STEM graduates are in full demand, yet females are still represented as a small percentage of the overall STEM workforce. There is literature regarding data that compares male and females that enroll and graduate from college STEM programs and the percentage of men and women in the STEM workforce. Additional research is needed about the academic achievement of females in specific academic settings to help close the gender gap between males and females in STEM careers. According to Crowell (2017), this gender gap is an issue of equal access to opportunities since the STEM industry, in math and science areas, has higher salaries, lower employment rates, and greater job growth than many other professions in which a college degree is needed. With this in mind, the researcher used the expectancy-value theoretical model to underline the theoretical framework that further explains girls' academic performance in math and science in single-sex schools. The next chapter will describe the methods that were used to conduct research for this study.

CHAPTER III

METHODS

The purpose of this study was to compare the mathematics and science performance on the State Assessment of Educational Progress (SAEP) of eighth-grade girls in three schools in a large school district in Texas: a single-sex (all-girls) school and two co-educational schools. This chapter begins with the research questions, followed by an explanation of the research design. After that, the sample and the population from which the sample was drawn is identified. Later, the data collection is explained, including a discussion regarding the instrumentation that will be used to measure the dependent variable. Finally, the research procedure, data analysis techniques, and limitations for the study are indicated and discussed in detail.

Research Questions

The study was guided by the following research questions:

RQ1: What relationship exists between the institution type (single-sex versus coeducational) and the mathematics performance of eighth-grade girls, controlling for student race/ethnicity and socioeconomic status?

RQ2: What relationship exists between the institution type (single-sex versus coeducational) and the science performance of eighth-grade girls, controlling for student race/ethnicity and socio-economic status?

Research Hypotheses

H_{01}: There is no relationship between the institution type (single-sex versus co-educational) and mathematics performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

H_{02}: There is no relationship between the institution type (single-sex versus co-educational) and the science performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

Research Design

The study utilized a nonequivalent group, post-test only quasi-experimental design to conduct this study. According to Gribbons and Herman (1997), one type of quasi-experimental design includes a posttest only design of which allows the researcher to measure an outcome between a comparison and intervention group. Table 3.1 below provides a brief description of a quasi-experimental research design.

Table 3.1

Quasi-experimental research design

Experiment Group	Assignment	Treatment	Outcome
Experiment: Eighth-grade girls at a single-gender school	R	X	O1
Control: Eighth-grade girls at a co-educational school	R		O2

This study used secondary end-of-year data collected during the 2015-2016 school year for eighth-grade female students from a single-sex (all-girls) school and two co-educational schools. In the case of the single-sex school, students have selected to attend, whereas students at the other two co-educational schools may attend because they are zoned to the school or because they have opted to attend. According to Mills and Gay (2016), this set of research conditions meets the criteria for a quasi-experimental design.

Setting and Population

The study was conducted in a large school district in Texas. Based on the 2015-2016 Texas Academic Performance Report (TEA, 2016), there are over 20 middle schools in the district with over 33,000 middle school students. According to the Texas Education Agency (2016), the ethnic distribution of the district was 24.4% African American, 62.0% Hispanic, 8.5% White, 0.2% American Indian, 3.7% Asian, 1.0% Pacific Islander, and 1.1% two or more races. There were 76.5% economically vulnerable students[1] and 23.5% non-economically vulnerable students with 30.3% English Language Learners (ELL) students. There were also 1.1% students with disciplinary placements and 64.2% vulnerable students for the research district. The district offers a robust portfolio of magnet schools that allows families to choose the type of school that will best meet their child's academic needs. The magnet programs offered by the district include single-sex college preparatory schools. For the district used in this research, single-sex schools are schools of choice which have admission requirements for its students. The traditional schools used in this research are labeled neighborhood schools that have no admission requirements for its students.

Sample and Sampling Techniques

The research sample included eighth-grade girls from three middle schools in the same large urban Texas school district. There is one single-sex, all-girls school in the district with 115 eighth grade students in the 2015-2016 school year. The ethnic distribution of the single-sex school according to TEA (2017) was 53.9% African American, 39.6% Hispanic, 2.1% White, 0.6% American Indian, 2.4% Asian, 0.2%

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[1] An economically vulnerable student is one who is eligible for free or reduced-price meals under the National School Lunch and Child Nutrition Program (TEA, 2007).

Pacific Islander, and 1.1% Two or more Races. Seventy percent of the students were economically vulnerable, with 1.6% English Language Learners (ELL). There were also 0.4% students with disciplinary placements and 32.4% of vulnerable students at this research site.

After the single-sex school was selected, the researcher used purposive sampling to select the two additional comparison schools. Purposive sampling, according to Crossman (2017), is the non-probability selection of participants with certain characteristics of a population. The other two participating campuses were chosen based on their African American and Hispanic enrollment and their location. The comparison schools were attended by the participants for whom no choice was available, or the participants did not meet the requirements of the single-sex school. Specifically, the comparison schools were selected because they were the schools that students from single-sex schools would have attended if they had attended their neighborhood schools. Moreover, students from the coeducational schools were from the same postal zip codes as those of the singe-gender school. By selecting students from the same zip code, the participants were of similar socioeconomic status (Taber et al., 2016). According to Bradley and Corwyn (2002), socioeconomic status (SES) is the quantification of an individual or family's access to financial capital, human capital, and social capital. There is a strong positive correlation between SES and academic achievement, indicating that schools of similar SES will likely experience similar academic achievement (Reardon, 2016; Lam, 2017; Muller, 2018).

From those two comparison schools, the researcher utilized propensity score matching to identify the girls to include in the comparison groups. Propensity score matching entails forming matched sets of treated and untreated subjects who share similar propensity scores (Austin, 2011). According to Nicholas and Gulliford (2008), the propensity is an individual's probability of being treated with the intervention given certain information about the individual. The propensity score is a single metric that summarizes all the information from explanatory variables that estimates the probability of a participant receiving treatment. This study utilized race/ethnicity and zip code as covariates and the probability of attending the single-sex school was the dependent variable for the calculation of the propensity score. By using propensity score matching, the researcher sought to minimize selection bias. The characteristics used to create a matched sample include student sex (all female), grade, and similar demographic characteristics (age, sex, race, and income level).

The researcher conducted a power analysis using GPower software to determine the minimum sample sizes for the study. An effect size of 0.09 was used from a meta-analysis conducted by Pahlke, Hyde, and Allison (2014) that compared the effects of single-sex and coeducational schooling on students' mathematics performance and attitudes. Based on the assumption of 0.80 power and an alpha of 0.05, one hundred twenty-four participants were the minimum sample size for the multiple regression analysis with the math SAEP score as the dependent variable. An effect size of 0.20 was used from a study conducted by Pahlke, Hyde, and Allison (2014) that compared the effects of single-sex and coeducational schooling on students' science performance and attitudes. Based on the assumption of 0.80 power and an alpha of 0.05, fifty-nine participants is the minimum sample size for the multiple regression analysis with the science SAEP score as the dependent variable.

Measures

Based on the review of the literature presented in the previous chapter, several factors have been identified as key predictors of math and science achievement for girls. The key independent variable in this study is school type which will be measured as a categorical variable with two levels: single-sex school and co-educational school. The additional factors that will be controlled in this study are student race and ethnicity and family socioeconomic status. Race and ethnicity will comprise the following categorical dummy variables: African American (0/1), Latino (0/1), and White (0/1). The largest group (AA) will go undefined and serve as the reference group. For this study, there were two possible levels of socioeconomic status, middle class, and working-class, which are determined by a students' eligibility to receive reduced or free lunch. Students eligible to receive reduced or free lunch were categorized as low SES.

The two dependent variables used in this study are students' mathematics and science scores as measured by the SAEP which are a series of state-mandated standardized tests used in Texas public schools that assesses students' knowledge of Texas Essential Knowledge and Skills learned in their particular grade level (Clark, 2011). The SAEP scores were measured using scaled SAEP scores which is a conversion of the raw score to a scale that is common to all test forms and that takes into account the difficulty of test questions (TEA, 2017c). For the eighth-grade mathematics SAEP, the range of scaled scores is 1005 to 2236. For the eighth grade science SAEP, the range of scaled scores is 635 to 6256. One can interpret scale scores across different sets of test questions, allowing direct comparisons of student performance between specific sets of test questions from different test administrations.

Data Collection

The secondary or historical data utilized in the study was student-level data from the Public Education Information Management System (PEIMS). PEIMS "encompasses all data requested and received by TEA about public education, including student demographic and academic performance, personnel, financial, and organizational information" (TEA, 2018, p. 1). PEIMS data was disaggregated to obtain the three-year SAEP results and student demographic information that comprised the variables of the study. The end-of-year data for 2015-2016 was utilized in the study.

Data Analysis

To answer the two research questions, the researcher tested the hypothesis that controlling for students' socioeconomic status (SES) and race/ethnicity, being in a single-sex institution was a significant predictor of students' mathematics or science SAEP scores. The dependent variables were mathematics or science SAEP score, which are scale or continuous variables. The predictive variables were students' socioeconomic status (SES) and race/ethnicity, which were dichotomous variables. Since these are predictive analyses, multiple linear regression was used to answer the research questions. The following is a mathematical representation of the multiple regression model:

$$Y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \alpha + e_i$$

In this model, X_1 represents student SES, X_2 represents student race/ethnicity, and X_3 represents the students' school type (single-gender or co-educational). The dependent variable in this model is denoted by Y, the intercept of the regression line is denoted by α, and the residuals or errors of the regression line are denoted by e_i.

To conduct a multiple linear regression, several key assumptions were tested and verified. First, a linear relationship existed between the dependent variable and the independent variables. Scatter plots were used to visually represent whether a linear relationship exists. Also, multiple regression assumes that the independent variables are not highly correlated. Variance Inflation Factor (VIF) values and tolerance levels are used to determine multicollinearity. According to Hair et al. (1995), 10 is the maximum level of VIF for regression models to be considered viable. Tolerance, the reciprocal of VIF, should have values greater than 0.2 or 0.1 (Hair et al., 1995). If VIF and tolerance do meet the aforementioned criteria, then multicollinearity will be problematic. Therefore, the researcher sought a VIF value of less than 10 and a tolerance greater than 0.1. Next, to conduct a multiple linear regression, the residuals must be normally distributed. A quantile-quantile (Q-Q) plot was generated and examined to establish normality for the residuals. Finally, the variance of the error terms must be similar across the values of the independent variables. A plot of standardized residuals versus predicted values indicated that points were relatively equally distributed across the values of the independent variables. Figure 3.1 represents the research process for the study.

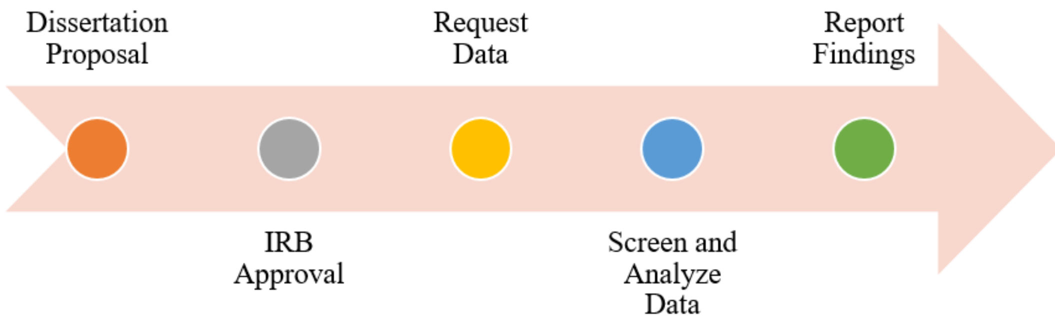

Figure 3.1. Study timeline

Summary

This chapter presented the methodology that will be utilized to conduct the study. It discussed the research questions, hypotheses, research design, variables, population and sample, instrumentation and data collection, data analysis, and the research process. Each of these components will serve to fulfill the purpose of the study, which is to compare the mathematics and science performance on the State Assessment of Educational Progress (SAEP) of eighth-grade girls in three schools in a major urban Texas school district: a single-sex (all-girls) school, a co-educational school with majority African American enrollment, and a co-educational school with majority Hispanic enrollment school.

Chapter IV

RESULTS

Introduction

The purpose of this study was to compare the performance of girls in math and science at an all-girls school with that of girls at two co-educational middle schools in the same district. The researcher sought to evaluate the impact on attending a single gender school for primarily historically marginalized eighth-grade girls. This chapter reports on the findings from the analysis of the differences in SAEP eighth grade mathematics and science scores. The research questions and respective hypotheses were as follows:

RQ_1: What relationship exists between the institution type (single-sex versus coeducational) and the mathematics performance of eighth-grade girls, controlling for student race/ethnicity and socioeconomic status?

H_{01}: There is no relationship between the institution type (single-sex versus co-educational) and mathematics performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

RQ_2: What relationship exists between the institution type (single-sex versus coeducational) and the science performance of eighth-grade girls, controlling for student race/ethnicity and socio-economic status?

H_{02}: There is no relationship between the institution type (single-sex versus co-educational) and the science performance of eighth-grade girls when controlling for student race/ethnicity and socioeconomic status.

This chapter will present the descriptive statistics, assumptions for analysis, and results of the analysis.

Descriptive Statistics

A review of the data revealed missing observations for some participants included in the data set. Participants with missing SAEP scores were removed from the data set before the descriptive statistics were calculated. Table 4.1 displays the number of students who took the SAEP examination by the year. A total of 441 participants completed both the mathematics and science SAEP examination across the three schools selected for the study.

Table 4.1

Number of students tested by year

Year	Frequency	Percent
2014 - 2015	204	46.3
2015 - 2016	237	53.7
Total	441	100.0

Table 4.2 displays the number of participants who completed both the mathematics and science SAEP examination for each school.

Table 4.2

Sample size by school

Year	Frequency	Percent
Solomon Middle	109	24.7
David Middle	212	48.1
Naomi Academy for Girls	120	27.2
Total	441	100.0

Figure 4.1 displays the distribution of the participants by race and ethnicity. The majority of the participants were African American (63.04%). Hispanics were the next most populous group, comprising 34.24% of the sample. No other race comprised more than 2% of the sample.

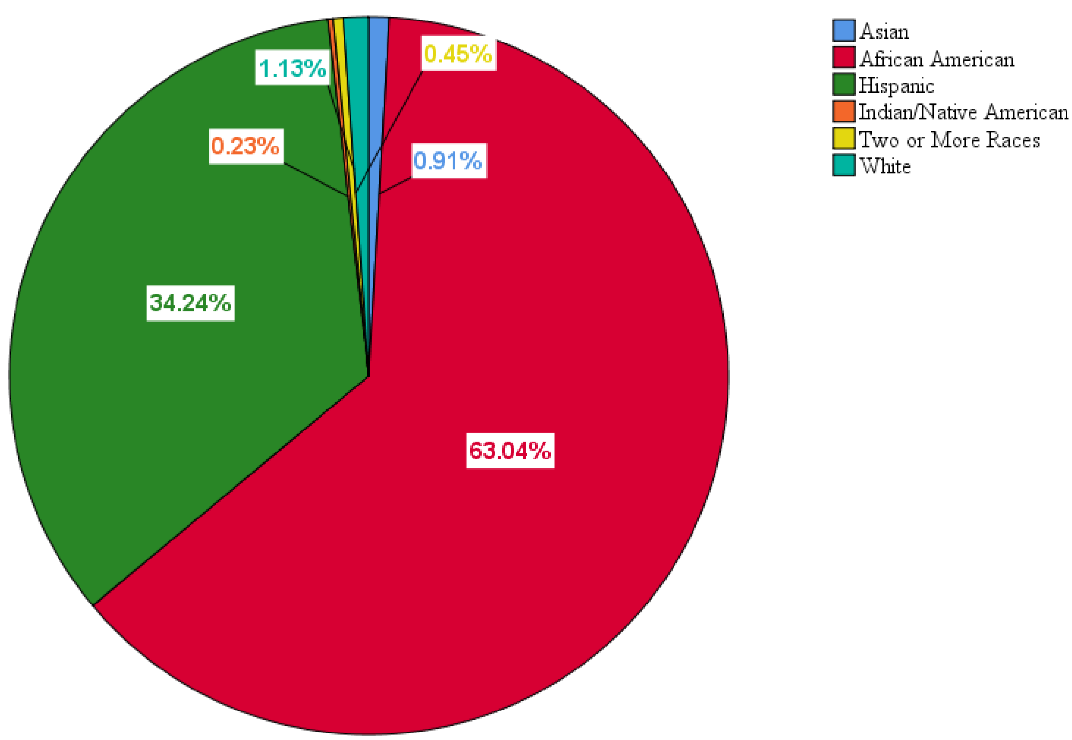

Figure 4.1. Distribution of participants by race and ethnicity

Table 4.3 displays the distribution of the participants by race for each year. For each year, the majority of the participants were either African American or Hispanic.

Table 4.3

Proportion of race and ethnicity by year

Year	Race and ethnicity	Frequency	Percent
2014 - 2015	African Americans	143	70.1
	Hispanic	60	29.4
	Two or more races	1	0.5
2015 - 2016	Asian	4	1.7
	African Americans	135	57.0
	Hispanic	91	38.4
	Indian/Native American	1	0.4
	Two or more races	1	0.4
	White	5	2.1

Table 4.4 displays the distribution of the participants by race for each school. For each school, the majority of the participants were either African American or Hispanic.

Table 4.4

Proportion of race and ethnicity by school

School	Race and ethnicity	Frequency	Percent
Solomon Middle	African Americans	83	76.2
	Hispanic	25	22.9
	Indian/Native American	1	0.9
David Middle	Asian	3	1.4
	African Americans	125	59.0
	Hispanic	80	37.7
	Two or more races	1	0.5
	White	3	1.4
Naomi Academy for Girls	Asian	1	0.8
	African Americans	70	58.3
	Hispanic	46	38.3
	Two Races or more	1	0.8
	White	2	1.7

Figure 4.2 displays the distribution of the participants by economic vulnerability status. The majority of the participants were considered economically vulnerable (75.06).

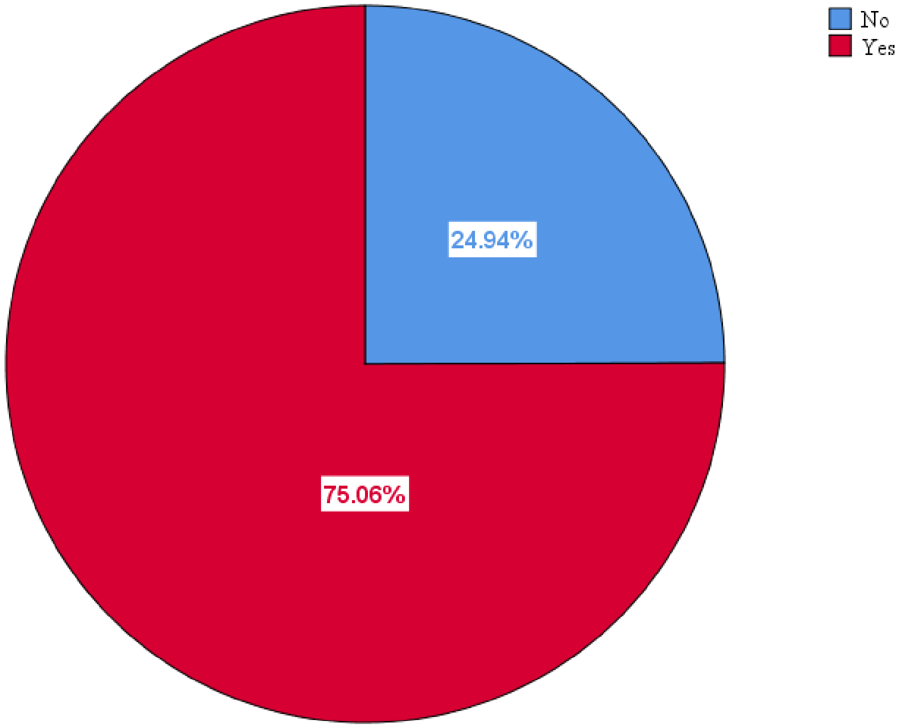

Figure 4.2. Distribution of participants by Economic Vulnerability status

Table 4.5 displays the frequency of economic vulnerability status of participants by year.

Table 4.5

Proportion of Economic Vulnerability status of participants by year

Year	Economically Vulnerable	Frequency	Percent
2014 - 2015	Yes	149	73.0
	No	55	270
2015 - 2016	Yes	182	76.8
	No	55	23.2

A chi-square analysis was conducted to test for differences in the distribution of economically vulnerable students across years. The results of the chi-square analysis reveal that there is no statistically significant relationship between students' economic vulnerability status and year of the examination *(χ^2 (1, 441) = 0.825, p = 0.364)*. Table 4.6 displays the frequency of the economic vulnerability status of participants by school. Solomon Middle School had the highest proportion of economically vulnerable participants (85.3%), while Naomi Academy had the lowest proportion of economically vulnerable participants (67.5%). A chi-square analysis was conducted to test for differences in the distribution of economically vulnerable students across schools. The results of the chi-square analysis revealed that there is a statistically significant relationship between students' economic vulnerability status and school type *(χ^2 (2, 441) = 9.908, p = 0.007)*.

Table 4.6

Frequency of economic vulnerability status of participants by school

School	Economically Vulnerable	Frequency	Percent
Solomon Middle	Yes	93	85.3
	No	16	14.7
David Middle	Yes	157	74.1
	No	55	25.9
Naomi Academy for Girls	Yes	81	67.5
	No	39	32.5

The descriptive statistics for the outcome variables in the study are presented in Tables 4.7 and 4.8. The mean SAEP mathematics score was highest for the 2014-2015 academic year. The mean SAEP science score also was highest for the 2014-2015 academic year. An independent sample t-test was conducted to determine whether significant differences existed between math or science SAEP scores for the two years in the study. The results of the independent sample t-test reveal that there was no significant difference between the math SAEP scores for the two years in the study (*t(439) = 1.583, p = 0.114*). The results of the independent sample t-test reveal that there was no significant difference between the science SAEP scores for the two years in the study (*t(439) = 0.913, p = 0.362*).

Table 4.7

Descriptive statistics for participants' eighth grade SAEP mathematics scores by year

Year	N	Minimum	Maximum	Mean	Std. Deviation
2014 - 2015	204	1450	1976	1625.49	97.62
2015 - 2016	237	1005	1941	1610.54	99.80
Total	441	1005	1976	1617.46	98.97

Table 4.8

Descriptive statistics for participants' eighth grade SAEP science scores by year

Year	N	Minimum	Maximum	Mean	Std. Deviation
2014 - 2015	204	2658	4940	3628.99	482.45
2015 - 2016	237	2533	4621	3590.74	397.32
Total	441	2533	4940	3608.43	438.66

The descriptive statistics for the outcome variables by race and ethnicity for each year are presented in Tables 4.9 and 4.10. Figures 4.3 and 4.4 display a comparison of the outcome variables by race and ethnicity. An analysis of variance (ANOVA) test was conducted to determine whether significant differences existed between math or science SAEP scores for the races/ethnicities included in the study. The results of the ANOVA test reveal that there was no significant difference between the math SAEP scores for the races/ethnicities included in the study (*$F(4, 441) = 0.889$, $p = 0.470$*). The results of the ANOVA test reveal that there was no significant difference between the science SAEP scores for the races/ethnicities included in the study (*$F(4, 441) = 1.199$, $p = 0.311$*).

Table 4.9

Descriptive statistics for participants' eighth grade SAEP mathematics scores by year for each race and ethnicity

Race and ethnicity	Year	Mean	Std. Deviation
Asian	2014 – 2015	NA	NA
	2015 – 2016	1756.50	132.34
African American	2014 – 2015	1620.34	95.84
	2015 – 2016	1602.75	85.33
Hispanic	2014 – 2015	1636.23	101.78
	2015 – 2016	1619.38	92.22
Indian/Native American	2014 – 2015	NA	NA
	2015 – 2016	1541.00	NA
Two or more races	2014 – 2015	1717.00	NA
	2015 – 2016	1520.00	NA
White	2014 – 2015	NA	NA
	2015 – 2016	1575.40	330.49

Table 4.10

Descriptive statistics for participants' eighth grade SAEP science scores by year for each race and ethnicity

Race and ethnicity	Year	Mean	Std. Deviation
Asian	2014 – 2015	NA	NA
	2015 – 2016	4048.25	365.90
African American	2014 – 2015	3599.29	468.90
	2015 – 2016	3561.10	367.83
Hispanic	2014 – 2015	3691.47	511.22
	2015 – 2016	3614.36	425.110
Indian/Native American	2014 – 2015	NA	NA
	2015 – 2016	3097.00	NA
Two or more races	2014 – 2015	4128.00	NA
	2015 – 2016	3775.00	NA
White	2014 – 2015	NA	NA
	2015 – 2016	3656.80	536.99

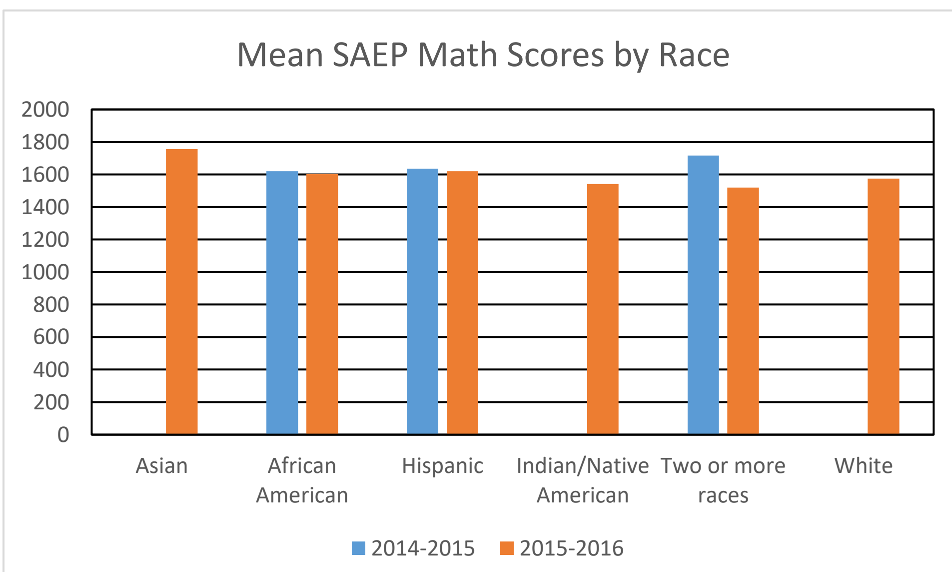

Figure 4.3. Mean SAEP mathematics scores by race for each year

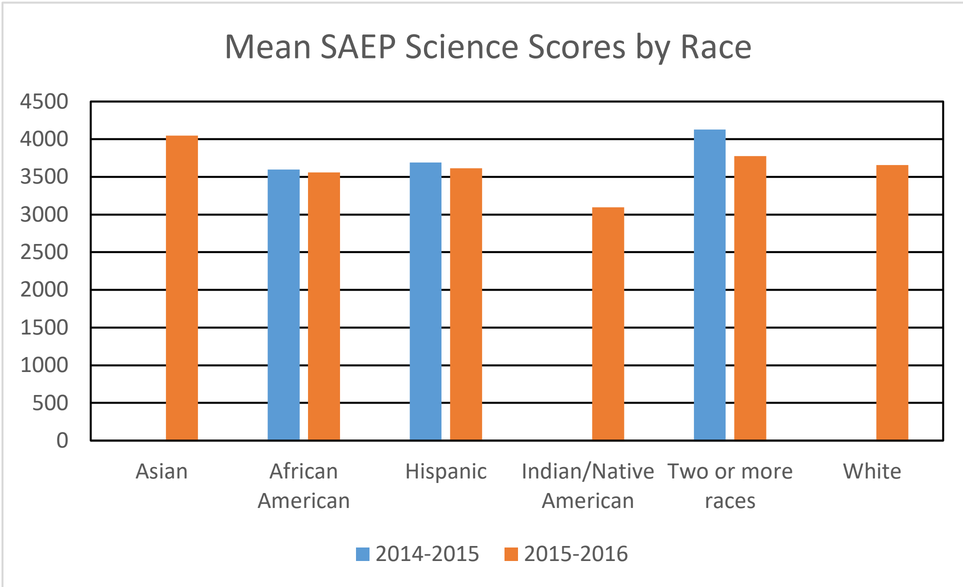

Figure 4.4. Mean SAEP science scores by race for each year

The descriptive statistics for the outcome variables by school for each year are presented in Tables 4.11 and 4.12. Figures 4.5 and 4.6 display a comparison of the outcome variables by school. An ANOVA test was conducted to determine whether significant differences existed between math or science SAEP scores for the schools included in the study. The results of the ANOVA test revealed that significant differences existed between the math SAEP scores for the schools included in the study ($F(2, 441) = 11.102$, $p < 0.001$). The results of the ANOVA test revealed that significant differences existed between the science SAEP scores for the schools included in the study ($F(2, 441) = 51.378$, $p < 0.001$).

Table 4.11

Descriptive statistics for participants' eighth grade SAEP mathematics scores by year for each school

School	Year	Mean	Std. Deviation
Solomon Middle	2014 - 2015	1611.17	81.33
	2015 - 2016	1574.49	82.20
David Middle	2014 - 2015	1604.25	89.78
	2015 - 2016	1619.41	121.10
Naomi Academy for Girls	2014 - 2015	1693.98	104.78
	2015 - 2016	1626.44	70.07

Table 4.12

Descriptive statistics for participants' eighth grade SAEP science scores by year for each school

School	Year	Mean	Std. Deviation
Solomon Middle	2014 - 2015	3369.63	351.37
	2015 - 2016	3445.10	367.54
David Middle	2014 - 2015	3589.09	393.42
	2015 - 2016	3490.17	413.74
Naomi Academy for Girls	2014 - 2015	4038.67	564.50
	2015 - 2016	3832.38	262.60

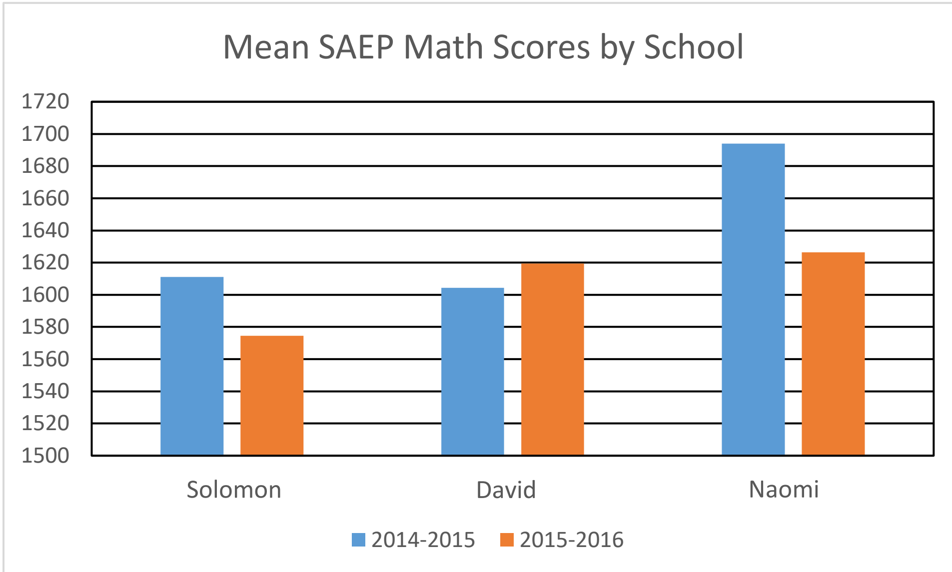

Figure 4.5. Mean SAEP mathematics scores by school for each year

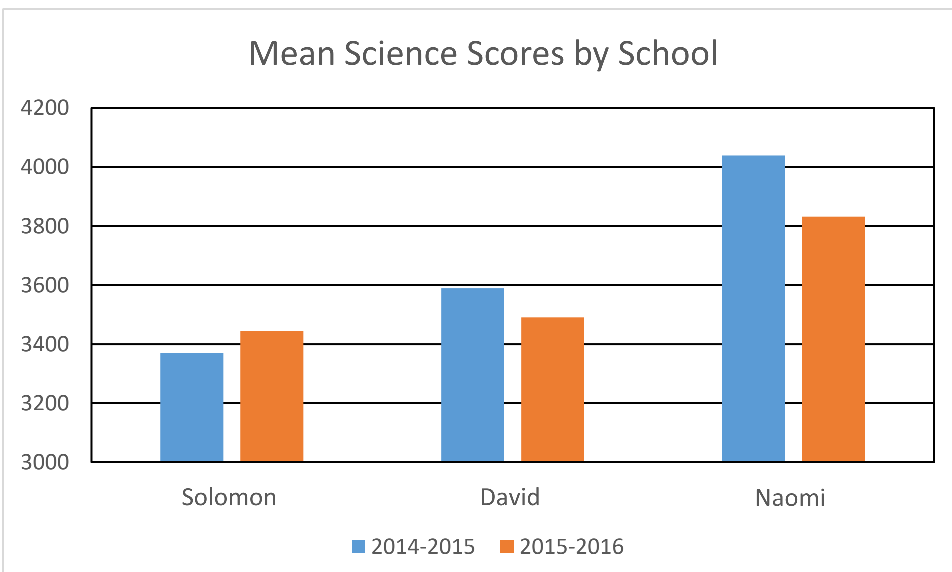

Figure 4.6. Mean SAEP science scores by school for each year

The descriptive statistics for the outcome variables by economic vulnerability status for each year are presented in Tables 4.13 and 4.14. Figures 4.7 and 4.8 display a comparison of the outcome variables by economically vulnerability status. An independent sample t-test was conducted to determine whether significant differences existed between math or science SAEP scores for the economic vulnerability status of the students included in the study. The results of the independent sample t-test revealed that significant differences existed between the math SAEP scores for the economic vulnerability status of the students included in the study ($t(441) = 0.195, p = 0.846$). The results of the independent sample t-test revealed that significant differences existed between the science SAEP scores for the economic vulnerability status of the students included in the study ($t(441) = -1.663, p = 0.097$).

Table 4.13

Descriptive statistics for participants' eighth grade SAEP mathematics scores by year for economic vulnerability status

Economically Vulnerable	Year	Mean	Std. Deviation
No	2014 - 2015	1617.95	115.45
	2015 - 2016	1613.78	114.03
Yes	2014 - 2015	1628.27	90.44
	2015 - 2016	1609.57	95.40

Table 4.14

Descriptive statistics for participants' eighth grade SAEP science scores by year for economic vulnerability *status*

Economically Vulnerable	Year	Mean	Std. Deviation
No	2014 - 2015	3624.29	556.62
	2015 - 2016	3712.85	378.25
Yes	2014 - 2015	3630.72	454.10
	2015 - 2016	3553.84	396.549

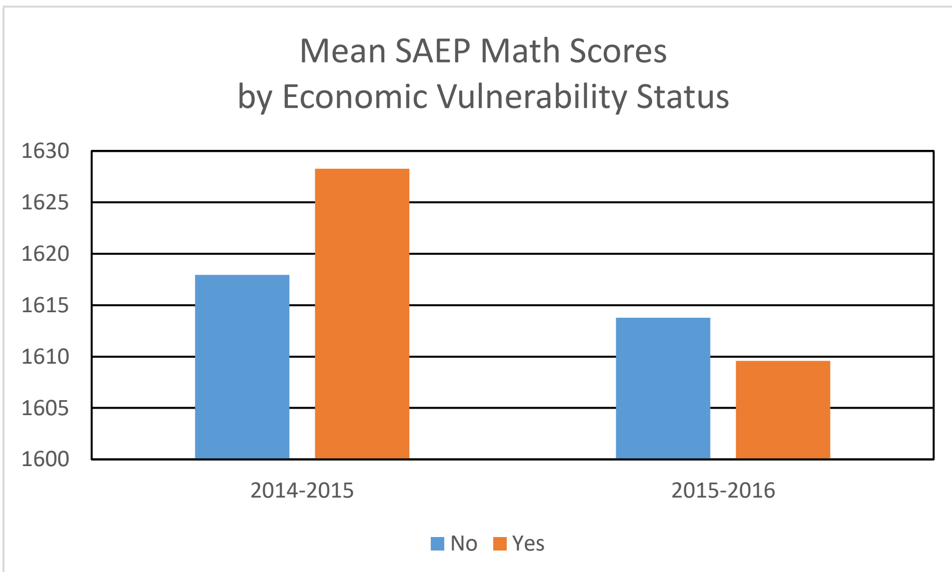

Figure 4.7. Mean SAEP mathematics scores by year for economic vulnerability *status*

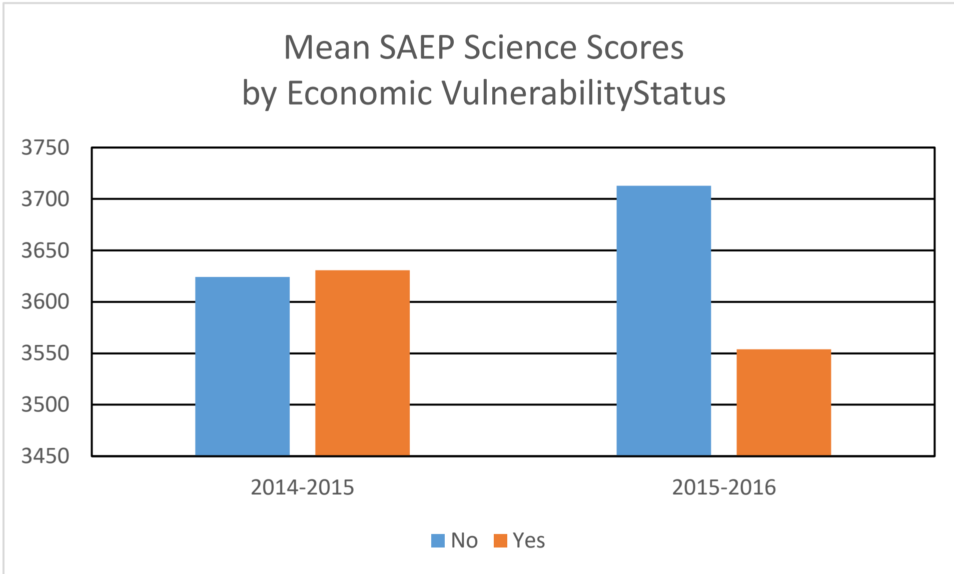

Figure 4.8. Mean SAEP science scores by year for economic vulnerability *status*

Research Question 1

To examine the effects of race and ethnicity, economic vulnerability status, and school type on mathematics SAEP scores among participants, a multiple linear regression analysis was conducted. Several key assumptions must be satisfied to obtain meaningful results from a multiple linear regression analysis. First, a linear relationship must exist between the dependent and independent variables. By definition, the relationship between a binary categorical variable and a continuous dependent variable is nonlinear. Second, the residuals must be normally distributed. The probability-probability (P-P) plot of the standardized residuals can be used to determine if the residuals are normally distributed. Figure 4.9 indicates that the residuals are normally distributed as shown by the proximity of the data points to the diagonal.

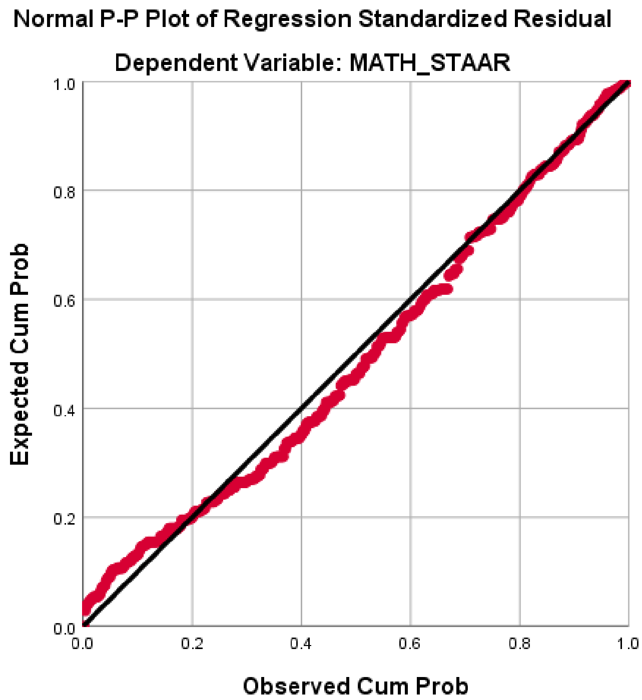

Figure 4.9. Normal P-P plot of regression standardized residual

The next assumption that must be satisfied to obtain meaningful results from a multiple linear regression is that multicollinearity cannot exist among the independent variables. Tolerance and the variance inflation factor (VIF) are used to determine whether multicollinearity exists among the independent variables. To ensure no multicollinearity exists, the tolerance must be greater than 0.2 and the VIF must be less than 10. Table 4.15 displays the tolerance and VIF values for the independent variables. The data meet the assumption for no multicollinearity.

Table 4.15

Collinearity statistics for the independent variables

Variable	Collinearity Statistics	
	Tolerance	VIF
Asian	0.981	1.019
African American	0.923	1.084
Indian/Native American	0.987	1.013
Two or more races	0.989	1.011
White	0.958	1.044
Solomon Middle	0.839	1.146
Naomi Academy for Girls	0.872	1.192
Economically Vulnerable	0.950	1.053

Another assumption for multiple linear regression is independence among the values of the residuals. The Durbin-Watson statistic can be used to determine whether the residuals are independent. To satisfy the assumption of independence among the residuals, the Durbin-Watson value must be reasonably close to two. The Durbin-Watson statistic for the residuals in this study is 0.404. This value is relatively low and may be such due to the presence of noise in the system (Lee & Lund, 2004).

The final assumption for multiple linear regression is homoscedasticity, which is a similarity among the variance terms of the independent variables. A scatter plot of the residuals can be used to determine if homoscedasticity exists among the variance terms of the independent variables. Figure 4.10 displays the scatter plot of the residuals for the data used in this study. The plot reveals no pattern, indicating adequate homoscedasticity.

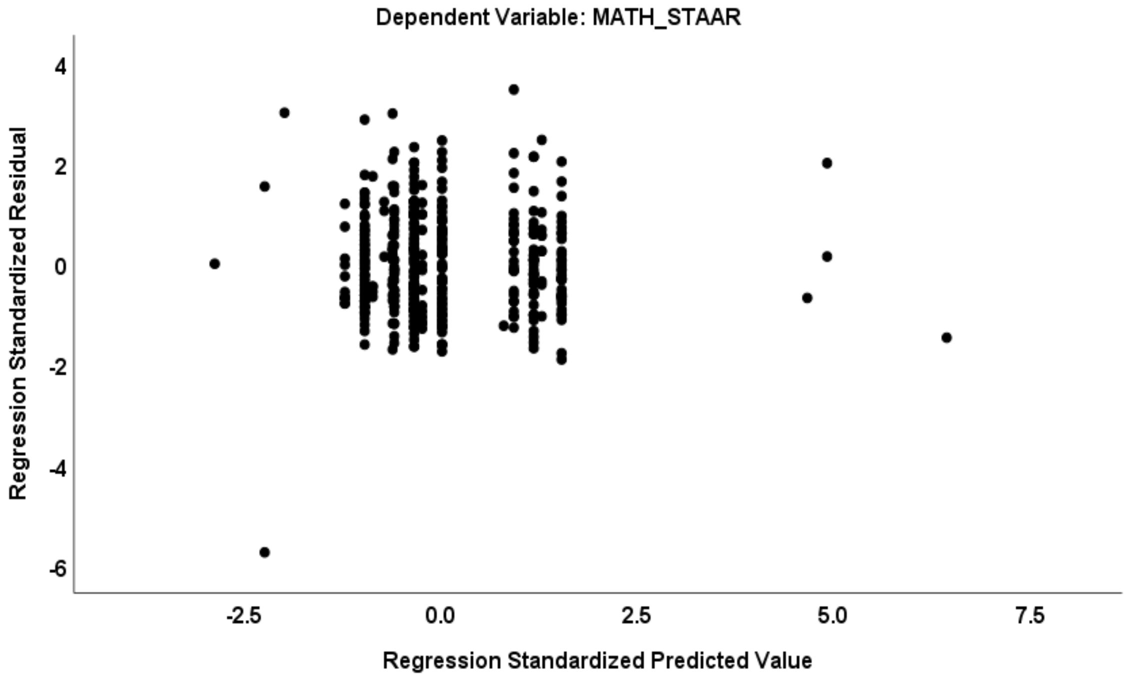

Figure 4.10.Scatter plot of standardized residual values vs. predicted values of the dependent variable

Research question one inquires whether a relationship exists between institution type and the mathematics performance on the SAEP examination, controlling for race and ethnicity and economic vulnerability status. A multiple linear regression model with SAEP mathematics scores as the dependent variable and race and ethnicity, economic vulnerability status, and school type as independent variables was used to answer this question. The following were the reference variables that were used for the analysis: Hispanic for race and ethnicity, No for Economic Vulnerability Status, and David Middle for School. The results of the regression model suggest that a significant proportion of the total variation in SAEP mathematics scores was predicted by race and ethnicity, economic vulnerability status, and school type *($F(440) = 4.490, p < 0.001$)*. The R^2

statistic indicates that 6.8% of the variance in the SAEP mathematics scores was predicted institution type, race and ethnicity, and economic vulnerability status

For this model, the unstandardized partial slope (133.17) for Asian was significantly different from the reference group, which was Hispanic. Therefore, an Asian student who took the SAEP mathematics examination scored, on average, 133 points higher than a Hispanic student scored, all else equal. The unstandardized partial slope (45.74) for COED School was significantly different from the reference group, which was David Middle, therefore, a student who attended a COED school scored, on average, 45 points lower than a student who attended a Naomi Academy for Girls, all else equal. Table 4.16 displays the coefficients for the multiple regression analysis.

Table 4.16

Coefficients for the regression model with Math SAEP as the dependent variable

Variable	B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	1658.871	11.035		150.333	.000
Asian	133.174	48.804	.128	2.729	.007
African American	-11.516	9.788	-.056	-1.176	.240
Indian/Native American	-72.127	96.713	-.035	-.746	.456
Two or more races	-17.499	68.633	-.012	-.255	.799
White	-52.067	44.261	-.056	-1.176	.240
Economically Vulnerable	-4.948	10.810	-.022	-.458	.647
COED SCHOOL	-45.744	10.401	-.206	-4.398	.000

Research Question 2

To examine the effect of race and ethnicity, economic vulnerability status, and school type on science SAEP scores among participants, a multiple linear regression analysis was conducted. Several key assumptions must be satisfied to obtain meaningful results from a multiple linear regression analysis. First, a linear relationship must exist between the dependent and independent variables. Inherently, the relationship between a binary categorical variable and a continuous dependent variable is linear. Second, the residuals must be normally distributed. Figure 4.11 indicates that the residuals are normally distributed as shown by the proximity of the data points to the diagonal in the P-P plot.

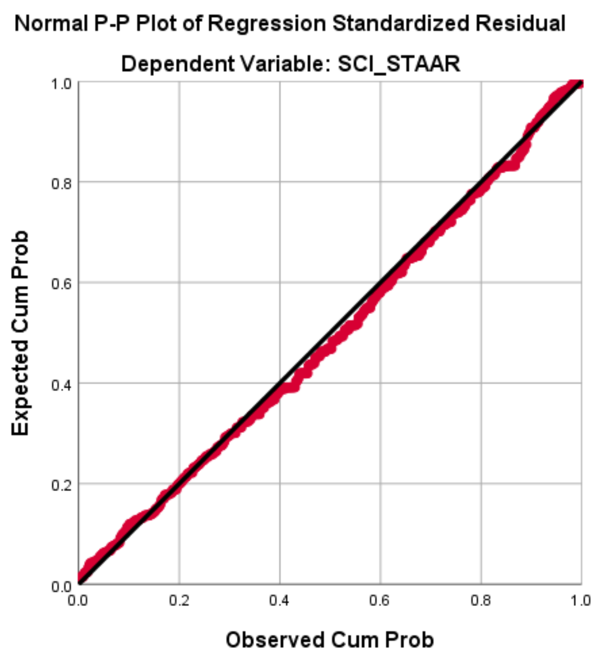

Figure 4.11. Normal P-P plot of regression standardized residual

The next assumption that must be satisfied to obtain meaningful results from a multiple linear regression is multicollinearity cannot exist among the independent variables. Tolerance and the variance inflation factor (VIF) are used to determine whether multicollinearity exists among the independent variables. To ensure no multicollinearity exists, the tolerance must be greater than 0.2 and the VIF must be less than 10. Table 4.17 displays the tolerance and VIF values for the independent variables. The data meet the assumption for no multicollinearity.

Table 4.17

Collinearity statistics for the independent variables

Variable	Collinearity Statistics	
	Tolerance	VIF
Asian	0.981	1.019
African American	0.923	1.084
Indian/Native American	0.987	1.013
Two or more races	0.989	1.011
White	0.958	1.044
Solomon Middle School	0.839	1.146
Naomi Academy for Girls	0.872	1.192
Economically Vulnerable	0.950	1.053

Another assumption for multiple linear regression is independence among the values of the residuals. The Durbin-Watson statistic can be used to determine whether the residuals are independent. To satisfy the assumption of independence among the residuals, the Durbin-Watson value must be reasonably close to two. The Durbin-Watson statistic for the residuals in this study is 0.997. This value is relatively low and may be such due to the presence of noise in the system (Lee & Lund, 2004).

The final assumption for multiple linear regression is homoscedasticity, which is similarity among the variance terms of the independent variables. A scatter plot of the residuals can be used to determine if homoscedasticity exists among the variance terms of the independent variables. Figure 4.12 displays the scatter plot of the residuals for the data used in this study. The plot reveals no pattern, indicating adequate homoscedasticity.

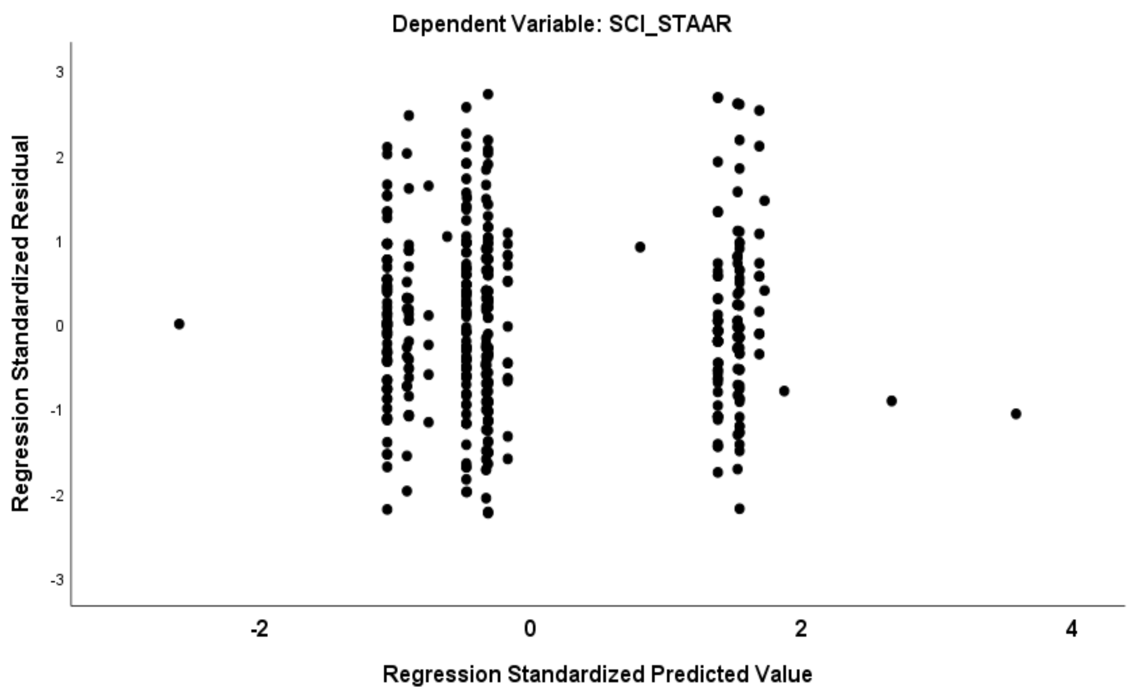

Figure 4.12. Scatter plot of standardized residual values vs. predicted values of the dependent variable

Research question two inquires whether a relationship exists between institution type and the science performance on the SAEP examination, controlling for race and ethnicity as well as economic vulnerability status. A multiple linear regression model with SAEP science scores as the dependent variable and race and ethnicity, economic vulnerability status, and school type as independent variables was used to answer this question. The following were the reference variables that were used for the analysis: Hispanic for race and ethnicity, No for Economic Vulnerability Status, and David Middle for School. The results of the regression model suggest that a significant proportion of the total variation in SAEP science scores was predicted by race and ethnicity, economic vulnerability status, and school type $(F(440) = 14.665, p < 0.001)$. The R^2 statistic indicates that 19.2% of the variance in the SAEP science scores was predicted by institution type, race and ethnicity, and economic vulnerability status.

For this model, the unstandardized partial slope (423.17) for Asian was significantly different from the reference group, which was Hispanic. Therefore, an Asian student who took the SAEP science examination scored, on average, 423 points higher than a Hispanic student did. The unstandardized partial slope (402.928) for Naomi Academy for Girls was significantly different from the reference group, which was COED School. Therefore, a student who attended Naomi Academy for Girls scored, on average, 403 points higher than a student who attended a COED School. Table 4.18 displays the coefficients for the multiple regression analysis.

Table 4.18

Coefficients for the regression model with science SAEP as the dependent variable

Variable	B	Std. Error	Standardized Coefficients Beta	t	Sig.
(Constant)	3917.061	45.544		86.007	.000
Asian	423.166	201.431	.092	2.101	.036
African American	-45.872	40.400	-.051	-1.135	.257
Indian/Native American	-417.133	399.166	-.045	-1.045	.297
Two or more races	235.903	283.272	.036	.833	.405
White	-51.204	182.680	-.012	-.280	.779
Economically Vulnerable	40.875	44.618	.040	.916	.360
COED School	-402.928	42.928	-.409	-9.386	.000

Summary

The purpose of this study is to compare the performance of girls in math and science at an all-girls school with that of girls at co-educational schools in the same district. The findings of this study will inform educational leaders regarding the effectiveness of single-gender schools in urban school districts. The results indicate greater performance on both the mathematics and science SAEP examination for participants who attended the single-gender school. Based on the results of the study, further research on factors that impact mathematics and science SAEP scores can provide vital information for educational leaders who seek to improve academic achievement among urban middle school girls.

Chapter V

DISCUSSION

Introduction

The purpose of this study was to compare the performance of girls in mathematics and science at an all-girls school with that of girls at co-educational schools in the same district. The study compared the performance of eighth-grade girls on the SAEP mathematics and science examination while controlling for race, socioeconomic status, and school type. The results of the study show greater achievement on the SAEP mathematics and science examinations for girls enrolled in single-sex schools when compared to girls of similar backgrounds who were enrolled in co-educational schools. The results of the study also indicated no significant difference in the mathematics and science SAEP examination scores based on socioeconomic status. Additionally, the study reveals a significant difference in mathematics and science SAEP scores only between Asian students and students of all other ethnic backgrounds. This chapter discusses how the findings of this study contribute to the understanding of girls' education in mathematics and science given previous knowledge. The chapter will also discuss how the findings of the study can assist educational practitioners. The chapter concludes with recommendations for future research.

Contribution to the study of girls' education in single-sex schools

The comparison of eighth-grade girls' performance on the math and science SAEP examination will contribute to the understanding of girls' education in math and science in myriad ways. First, the findings of the study indicate that girls attending single-sex schools score significantly higher on the SAEP examination in both mathematics and science when compared to the coeducational schools in the study. These results support the findings of Hirsch et al. (2017) who found that girls in single-sex schools demonstrate superior improvement in the STEM subjects of computer applications and engineering that their counterparts in co-educational settings. Also, the findings of this study support the earlier work of Carpenter (1985) who found that females attending single-sex schools perform better in all subjects than their peers in co-educational settings. Additionally, the findings of this study are consistent with the results of a study in Canada reported in the Educational Research Newsletter (2017) which compared eighth-grade girls attending a girls-only school to both girls and boys from coeducational classes. Female students from the study conducted in Canada achieved better grades in math and science when compared to both the girls and boys in the coeducational classes. This finding is consistent with the results of this study which reveal higher math and science SAEP scores for female students enrolled in a single-sex school.

A notable finding of this study is that SES was not a significant factor in the difference in the science and mathematics SAEP examination scores when controlling for other factors. This finding is inconsistent with the findings of Reardon (2016) who concluded that there are strong, positive district-level and student-level correlations between socioeconomic status and average academic achievement. Reardon (2016) examined the average test scores in 11,280 U.S. school districts in conjunction with the average SES level of the students enrolled in the district. Specific findings indicate that socioeconomic context is a very powerful predictor of students' academic performance. In this study, the math and science SAEP scores of economically vulnerable students and students with no economic vulnerability were statistically similar. The SAEP math scores for one year included in the study were higher for economically vulnerable students when compared to students with no economic vulnerability.

Another important finding of this study is that Asian was the only demographic group that differed significantly from other demographic groups included in the study. Many studies document an academic achievement gap between White students and Black and Hispanic students (Green, 2001; Simpson, 1981; Jeynes 2008). This gap exists in almost every measure of educational programs, including standardized tests, grade point average, and graduation rate. However, the results in this study reveal no significant difference in SAEP mathematics and science scores for Whites and Blacks and Hispanics. As legislators and educators seek to eliminate the academic achievement gap between Whites and Blacks and Hispanics, the findings of this study suggest that the use of single-sex environments may be a solution.

Future Research

Based on the relevant literature and the results of the study, I present several recommendations for further research. The results of the regression model in this study for SAEP mathematics scores indicate that 7.2% of the variance in the scores was predicted by institution type, race, and economic vulnerability status. The results of the regression model in this study for SAEP science scores indicate that 20.2%. The R-square values for both models appear to be relatively low. However, because this study involves human behavior which cannot be accurately predicted, the R-squared value for both models may be acceptable. A common practice is to attempt to improve the R-square value of regression models even when the value is acceptable (Cribari-Neto & Zarkos, 1995). Future research may be conducted in which additional predictor variables are included in the model. For instance, the language of the students is a potential significant predictor variable and can be controlled for in regression models of future research. Besides, gender and race/ethnicity of the instructors are potential predictor variables and can also be controlled for in future research. Also, interaction terms of the current predictor can be included in regression models of future research.

Another recommendation for future research on single-sex schools involves the long-term social effects of single-sex schooling on attendees. Such research is necessary so that educational leaders who intend to utilize single-sex schools or classrooms will know that they are not trading short-term academic achievement for long-term dysfunction. Despite this legitimate concern, few studies exist on the long-term effect of single-sex schooling on students which compares their attendees with those educated in a co-educational setting. A systematic review conducted by the U.S. Department of Education (2005) concluded that no long-term differences were found for postsecondary test scores, college graduation rates, or graduate school attendance rates. However, this review included only two studies. As educational leaders decide whether to utilize single-sex spaces to improve academic outcomes, empirical research is needed to ensure students are offered the best opportunity for life-long success.

Of importance to the overall well-being of students who attend single-sex schools is the socioemotional development of the students. More research is also needed in this area to determine the effect of single-sex schooling on the non-cognitive factors that not only affect academic achievement but also affect the overall quality of life of the students. The results of existing studies are mixed with some studies indicating positive results for single-sex schooling, while others indicate no differences. What is lacking is a conceptual framework to connect the different outcome measures used in this realm so that studies are more applicable for practice.

Implications for Practitioners

There is a push for educational leaders to derive programs to close the academic achievement gap that exists primarily between White and Black and Hispanic students. One of the programs that is utilized is single-sex schooling for vulnerable populations. A concern of many educational leaders is whether single-sex schools are more effective than co-educational schools because recent research both supports and discredits single-sex schooling. However, an examination of the educational systems in the United States reveal the prevalence and effectiveness of single-sex schools in the U.S. educational system. Riordan (1990) found that the prevalence of coeducational schools in the United States is based on economics rather than academic achievement. As public education grew in the United States, educational leaders moved away from single-sex schools to be more efficient economically. In his study, Riordan (1990) urges practitioners to re-introduce single-sex schooling to public schools, as his analysis of single-sex schools in comparison to coeducational schools included controlling for family background and school characteristics. One of the primary criticisms of single-sex literature has been the confounding of single-sex effects with family background and school characteristics factors. A systematic review conducted by the U.S. Department of Education (2005) compared single-sex schools to co-educational schools using only studies that included statistical controls for individual and school differences. Of the studies included in the review, 23 indicated no significant findings, 15 indicated an advantage to single-sex education, and only one study indicated an advantage to co-educational schooling.

Additionally, a systematic review by Smithers and Robinson (2006) found no evidence of advantages for single-sex or coeducational schools due to the selectivity of single-sex schools. This study sought to compare a single-sex school with two co-educational schools with students of similar backgrounds and schools of similar characteristics. The results of this study indicated advantages for single-sex schooling when compared to co-educational schooling for eighth-grade girls. Based on the results of this study and relevant research, practitioners should conduct a thorough investigation of the research on the effectiveness of single-sex schools when contemplating offering single-sex educational spaces, especially for vulnerable students.

A critical implication for practitioners regarding single-sex education is the manner in which funding is allocated to single-sex schools. The NCLB Act of 2001 permitted the use of Innovative Program funds to support single-sex schools and classes consistent with applicable law. Many school districts allocate funds to schools based on a formulated school budgeting process. Single-sex schools are generally funded using the same formulas as coeducational schools. Because single-sex schools are usually part of an innovative program to improve the academic achievement of special populations, particularly vulnerable students, special subsidies should be available to single-sex schools. Such funds would be used to create and maintain academic programs designed to improve academic outcomes for vulnerable populations. The allocation of funds to single-sex schools designed to improve academic outcomes for vulnerable populations will demonstrate the commitment of district leaders to closing the achievement gap. The results of this study indicate significant improvements in academic areas as a result of single-sex schooling support the decision to commit more funds to single-schools, with the intent of improving the academic accountability rating of the district.

Summary

The purpose of this study was to compare the performance of eighth-grade girls on the SAEP mathematics and science examination while controlling for race, socioeconomic status, and school type. The results of the study indicated increased academic achievement for students enrolled in single-sex schools when compared to students enrolled in co-educational schools. The results of the study may become a significant finding in the body of knowledge in the area of STEM education of adolescent girls, as the results confirmed the effectiveness of single-sex education of eighth-grade girls in the areas of mathematics and science. Another important finding of the study is that no significant difference was found in math and science SAEP examination scores when controlling for the other independent variables in the study. Also of importance is the finding that there were no significant differences in the math or science SAEP scores between Whites and Black and Hispanics in the study. Concerning implications for practitioners, the study suggests that single-sex schools may be an option to help improve academic outcomes for vulnerable students. Consequently, district leaders should consider the allocation of additional funds to single-sex schools to assist with academic accountability ratings.

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HOUSTON INDEPENDENT SCHOOL DISTRICT
Hattie Mae White Educational Support Center 4400
West 1 8th Street · Houston, Texas 77092-8501

Grenita F.Lathan, Ph.D.
Interim Superintendent of Schools

www.HoustonISD.org
www.twitter.com/HoustonISD

Carla]. Stevens
Assistant Superintendent
Research and Accountability Department
Tel: 713-556-6700 • Fax 713 -556-6730

June 12, 2019

Delesa O'Dell Thomas (Franklin)
5906 Lawn Lane
Houston, TX 77088-5418

Dear Ms. Franklin:

The Houston Independent School District (HISD) is pleased to approve the research "A Comparative Analysis of Mathematics and Science Achievement in an All-Girls School." The study is being conducted in partial fulfillment of doctoral degree requirements at the University of Houston. The purpose of the research is to explore whether girls in single-gender schools have higher achievement than their peers in co-education settings. The projected date of study completion is December 31, 2019.

Approval to conduct the study in HISD is contingent on your meeting the following conditions:

- The target population is eighth-grade female students from a single-gender school. Students with similar background characteristics from at least two co-education schools will be used to create a comparison group.
- The study will use archival 2014- 2015 and 2015-2016 State of Texas Assessment of Academic Readiness (STAAR) student-level math and science data.
- Student-level STAAR fifth grade reading and math scores along with students' demographic characteristics, including gender, race/ethnicity, free or reduced lunch eligibility, and zip code, will be accessed to create matched comparison groups.
- An indicator, noting whether co-education students were enrolled in pre-advanced placement math and science classes in eighth grade, will be included in the data.
- A fee may be assessed if the HISD Department of Research and Accountability assists with data collection.
- This project does not interfere with the District's instructional/testing program.
- The researcher must follow the guidelines of HISD and the University of Houston regarding the protection of human subjects and confidentiality of data.
- While the Institutional Review Board (IRS) at the University of Houston is responsible for oversight of the study, the HISD Department of Research and Accountability will also monitor the study to ensure compliance to ethical conduct guidelines established by the Department of Health and Human Services, Office for Human Research Protection (OHRP) as well as the disclosure of student records outlined in Family Educational Rights and Privacy Act (FERPA).
- Data will only be reported in statistical summaries that preclude the identification of the district or any school participating in the study. Participants shall not be identified by name. Pseudonyms or non-identifying naming conventions must be used.
- In order to eliminate potential risks to study participants, the reporting of proposed changes in research activities must be promptly submitted to the HISD Department

of Research and Accountability for approval prior to implementing changes. Non-compliance with this guideline could affect the approval of future research studies in HISD.

- The final report must be submitted to the HISD Department of Research and Accountability within 30 days of completion of the written report.

Any other changes or modifications to the current proposal must be submitted to the Department of Research and Accountability for approval. Should you need additional information or have any questions concerning the process, please call (713) 556-6700.

Sincerely,

Carla Stevens
Assistant Superintendent
Research and Accountability Department

CS: vh
cc: Noelia Longoria
James McSwain